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NAVAER 01-60JKE-502

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Handbook
Maintenance Instructions
NAVY MODEL
FJ-4B
AIRCRAFT

SECTION V
POWER PLANT
AND
RELATED SYSTEMS

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Page No.	*Date of Latest Revision*
ii	1 August 1958
iii	1 May 1958
iv	1 August 1958
5-10	1 May 1958
5-10A	1 May 1958
5-10B	1 May 1958
5-14	1 August 1958
5-14A	1 August 1958
5-14B	1 May 1958
5-16	1 February 1958
5-18A	1 February 1958
5-18B	1 November 1957
5-19	1 November 1957
5-20	1 November 1957
5-21	1 November 1957
5-22A	1 February 1958
5-22B	1 February 1958
5-23	1 February 1958
5-25	1 November 1957
5-29	1 November 1957
5-30	1 November 1957
5-31	1 February 1958
5-32	1 November 1957
5-36	1 November 1957
5-37	1 November 1957
5-40	1 August 1958
5-41	1 August 1958
5-44	1 May 1958
5-45	1 May 1958
5-46	1 February 1958
5-48	1 November 1957
5-49	1 February 1958
5-51	1 November 1957
*5-52	1 November 1958
*5-53	1 November 1958
*5-54	1 November 1958
*5-55	1 November 1958
*5-57	1 November 1958
5-60	1 November 1957
*5-62	1 November 1958
5-65	1 November 1957
5-68	1 August 1958
5-69	1 May 1958
5-72	1 August 1958
5-72A	1 November 1957
5-72B	1 November 1957
5-73	1 November 1957
5-80	1 February 1958
5-81	1 February 1958
5-82	1 February 1958
5-84	1 May 1958
5-85	1 November 1957
5-86	1 November 1957
5-90	1 November 1957
5-91	1 November 1957
Index 1	1 May 1958

*The asterisk indicates pages revised, added or deleted by the current revision.

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Introduction to SECTION V

THIS HANDBOOK IS ONE OF A SERIES OF TEN which contain instructions required by using activities for the maintenance of Model FJ-4B aircraft. These are systems type handbooks. Each system is covered completely in a particular handbook. This includes all hydraulic, pneumatic, mechanical and electrical portions of the system. This has been done in order to assist the mechanic in becoming familiar with and in maintaining all phases of each system.

The "Power Plant and Related Systems" handbook contains only that engine maintenance data which is peculiar to the FJ-4B aircraft. For service and maintenance instructions on the J65-W-4B and J65-W-16A engines, refer to handbook AN 02B-35AAC-2. This handbook should be obtained and filed with Section V of the FJ-4B Handbook of Maintenance Instructions.

This handbook contains information necessary for the performance of class C and class D maintenance on those items of Contractor Furnished Equipment for which there are no separate handbooks. This handbook does not contain instructions for the overhaul of components. Such instructions are contained in separate handbooks of overhaul instructions for the individual components.

Instructions for the repair of aircraft structure are contained in the Handbook of Structural Repair (NAVAER 01-60JKD-503) for these aircraft.

Data necessary for obtaining replacement parts and complete identification of parts are contained in the Illustrated Parts Breakdown (NAVAER 01-60JKD-504) for these aircraft.

Weight and Balance Data are found in the applicable AN 01-1B-40 handbook for each of these aircraft.

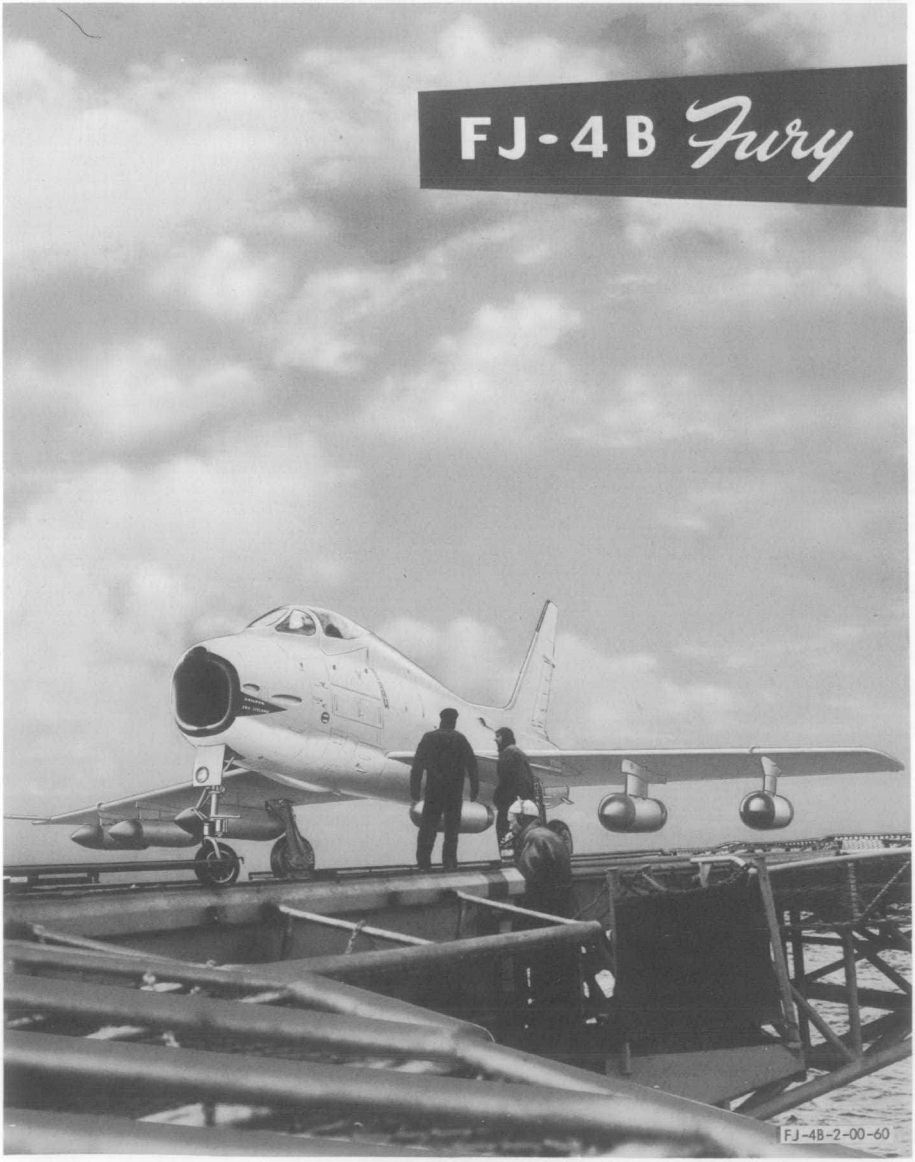
To identify and obtain these publications and handbooks covering separate items of equipment, refer to the Naval Aeronautic Publications Index (NAVAER 00-500).

BuAer Serial Numbers 139531 through 139555, 141444 through 141489 and 143493 through 143643 have been assigned to the FJ-4B. In addition, a lower case letter has been made a part of each serial number as it is painted on the aircraft. These lower case letters have been assigned to blocks of serial numbers as follows:

SERIAL NUMBER	LETTER
139531 through 139555	i
141444 through 141489	j
143493 through 143542	k
143543 through 143593	l
143594 through 143643	m

TABLE OF CONTENTS

Section V POWER PLANT AND RELATED SYSTEMS (Cont)



FJ-4B Airplane

GENERAL INFORMATION

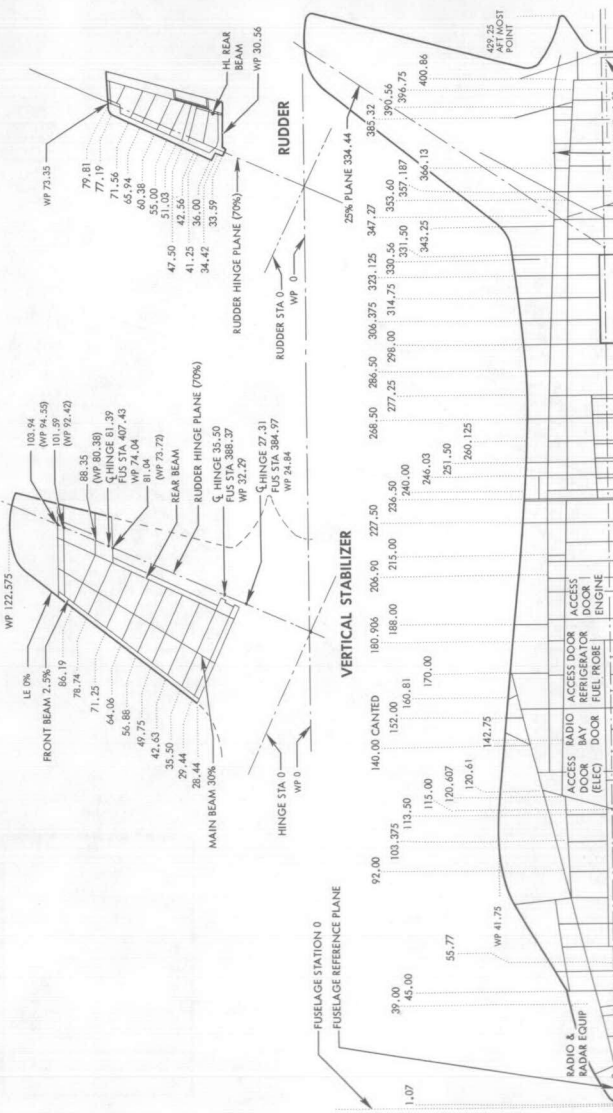


Figure No. 5-1. Airplane Stations (Sheet 1)

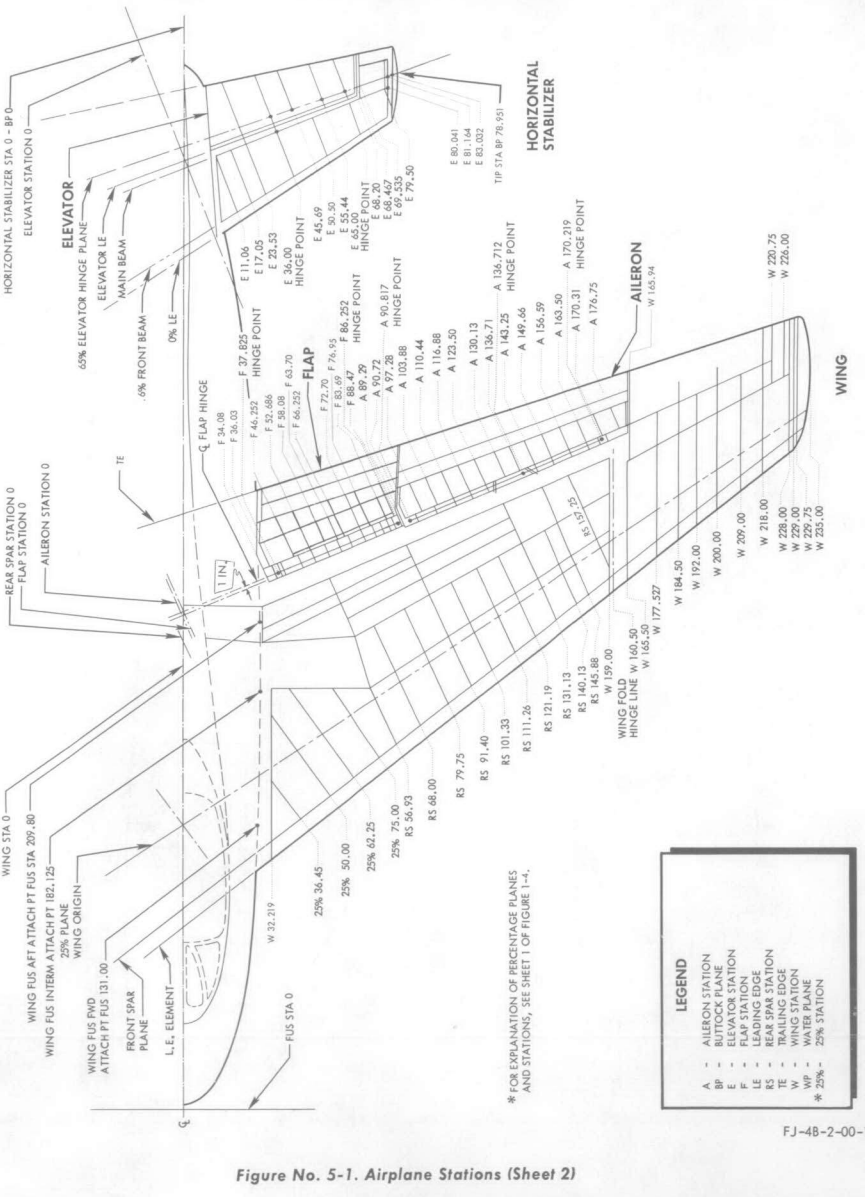


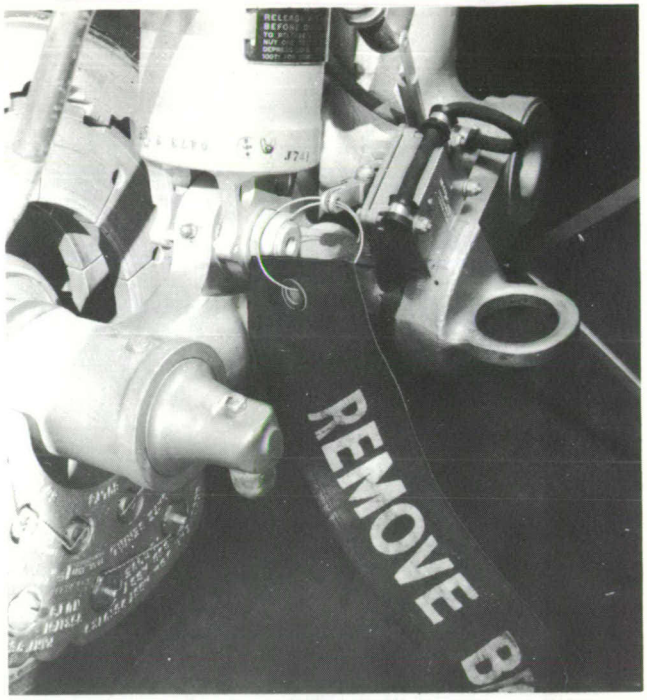
Figure No. 5-1. Airplane Stations (Sheet 2)

Warning Ground safety locks and pins are to be installed at all times, except for flight and gear retraction check. Remove immediately before flight and stow in cockpit map case.

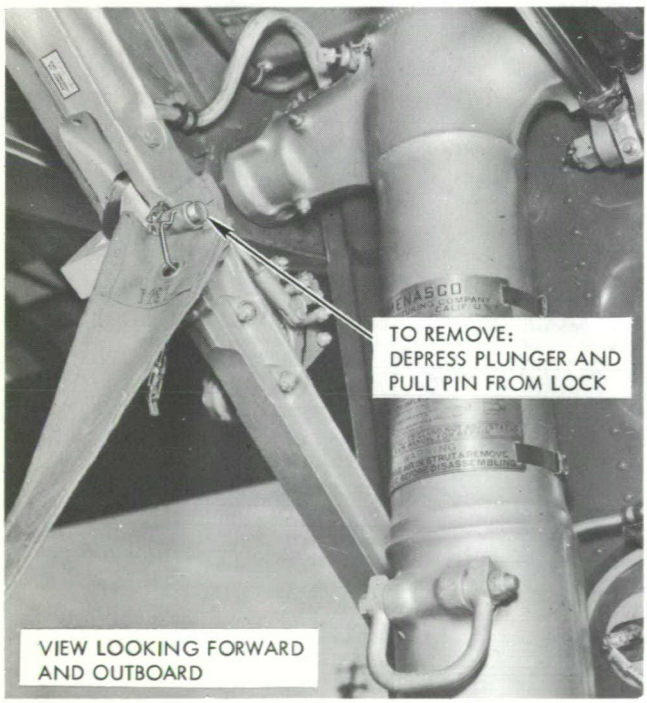
A time-saving method for performing certain testing procedures on the airplane (which normally would require the use of ground jacks) may be accomplished by disabling the ground safety switch. Attach a red warning flag, similar to the flags used on the landing gear ground safety locks, whenever the ground safety switch is disabled.

Warning When a red warning flag has been attached to the ground safety switch to indicate a disabled switch, never remove flag from the unit until switch has been properly connected.

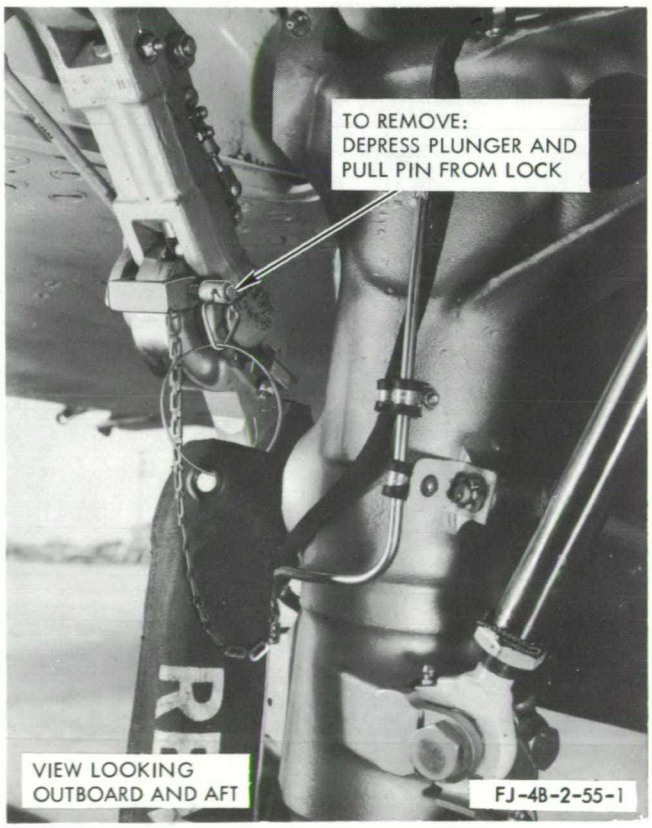
GROUND SAFETY SWITCH



NOSE LANDING GEAR GROUND SAFETY LOCK



MAIN LANDING GEAR GROUND SAFETY LOCK



Note There is no ground safety lock for the arresting gear.

Figure No. 5-2. External Ground Safety Locks and Pins

Warning

- Keep out of the cockpit unless maintenance is required.
- Always consider the emergency escape system loaded and armed.
- Know where the safety pins are and be certain of their installation.
- Do not manipulate linkage wihout full knowledge of the emergency escape system.
- Do not use linkage or handles as handgrips.
- The catapult cartridge, canopy remover, remover initiators and exactor are ordnance items and should be checked and maintained only by qualified personnel.

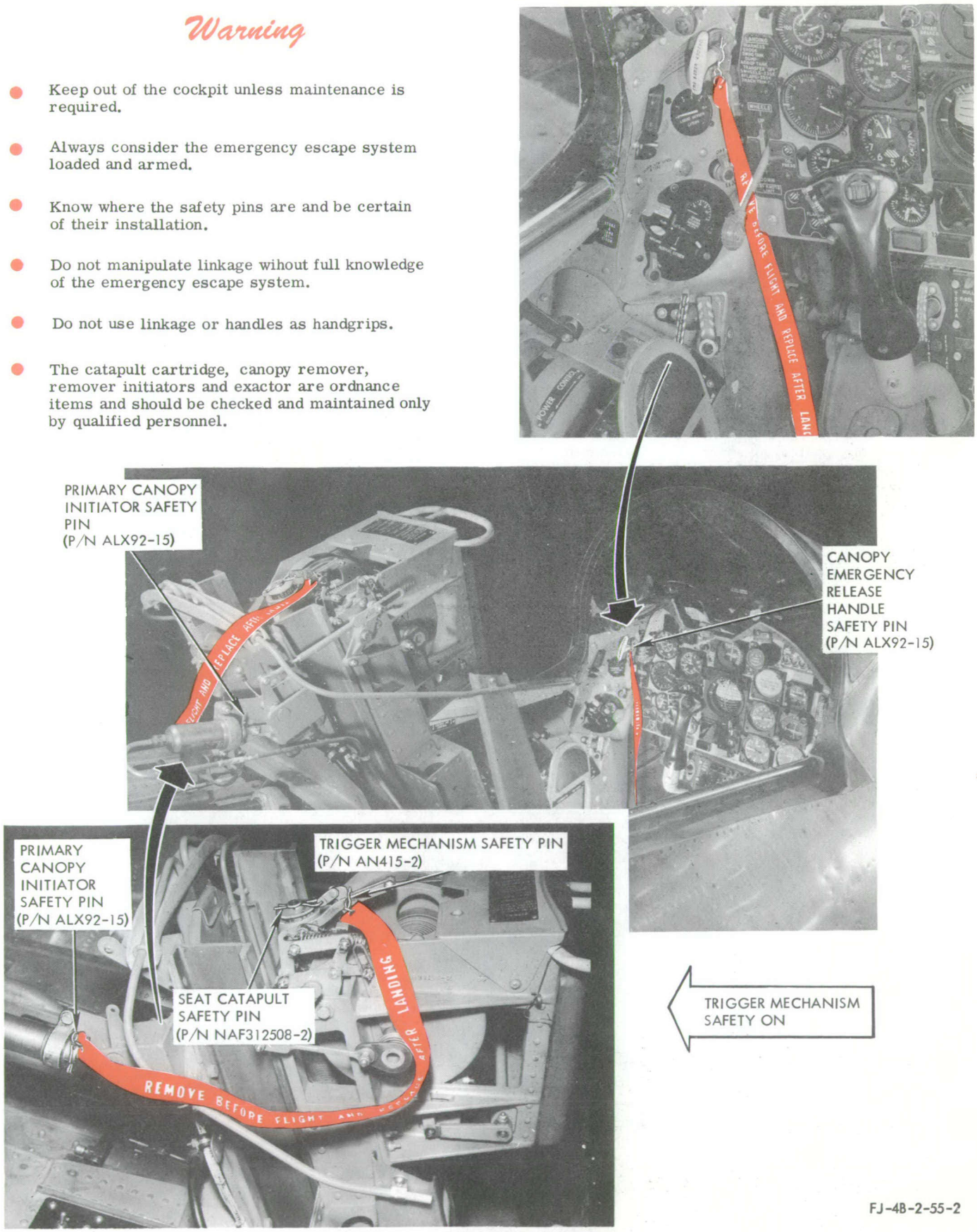
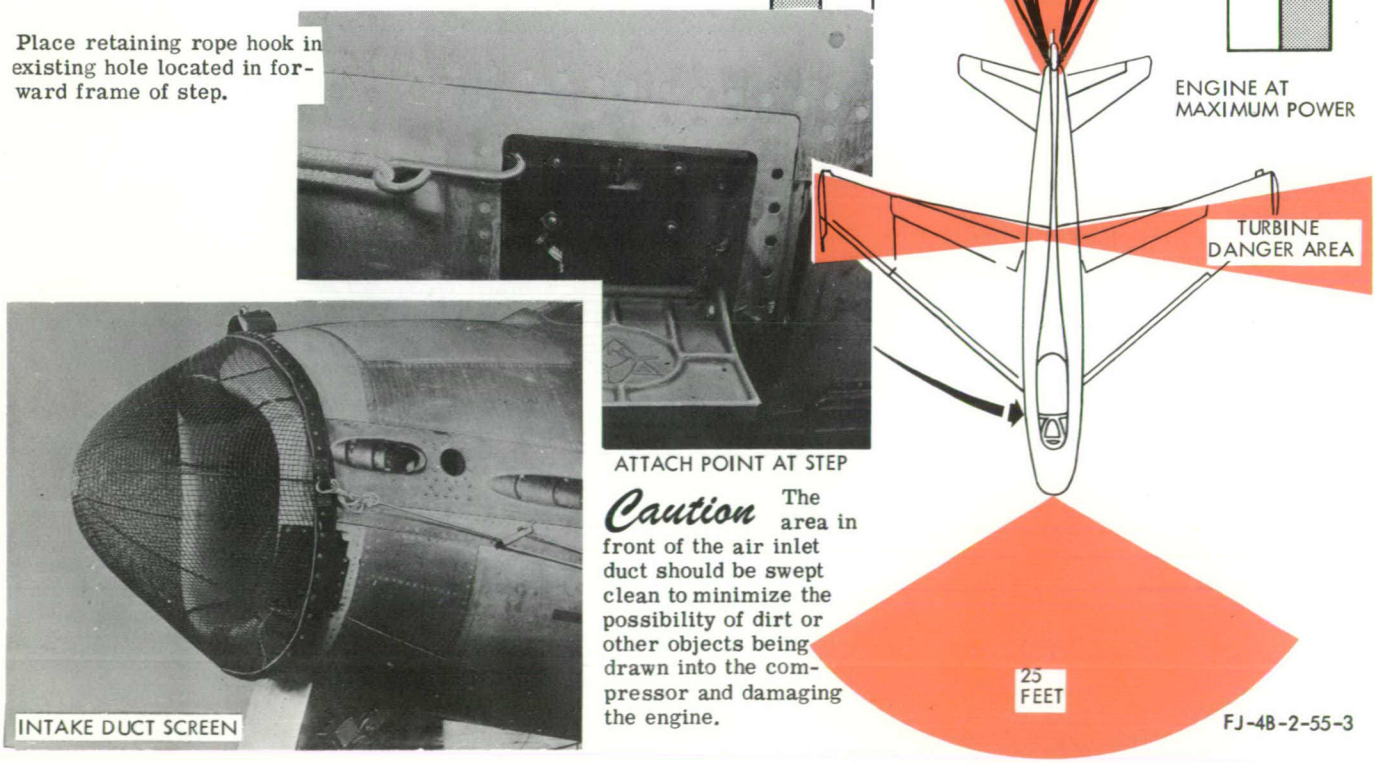


Figure No. 5-3. Emergency Escape System Ground Safety Pins

Warning

- Do not stand near the front of the air inlet duct while the engine is operating.
- Always approach the airplane from the side but not in the plane of rotation of the turbine when the engine is running.
- Avoid wearing hats or other loose clothing when working in the run-up area.
- Do not carry loose articles such as pencils, key rings or tools when near the air inlet duct.
- Do not foolishly experiment with the margin of safety by standing near, or feeling with your hand, the suction created by the engine.
- Do not stand on wing of the airplane while engine is operating, unless assistance is required during cockpit check-out or functional check of equipment.
- The loudest sustained noise produced by man is the noise of a jet engine operating at high rpm. Jet-engine noise is dangerous to personnel working in the immediate area. At distances from 50 to 200 feet, wear ear plugs and at distances within a radius of 50 feet, wear ear plugs and a type of over-the-ear protector. Prolonged exposure to jet-engine noise can cause pain and damage to the inner ear. Other effects of prolonged exposure are fatigue, nervousness and impairment of hearing.
- Do not stand at the edge of the blast area as the temperature could suddenly increase with engine speeds.

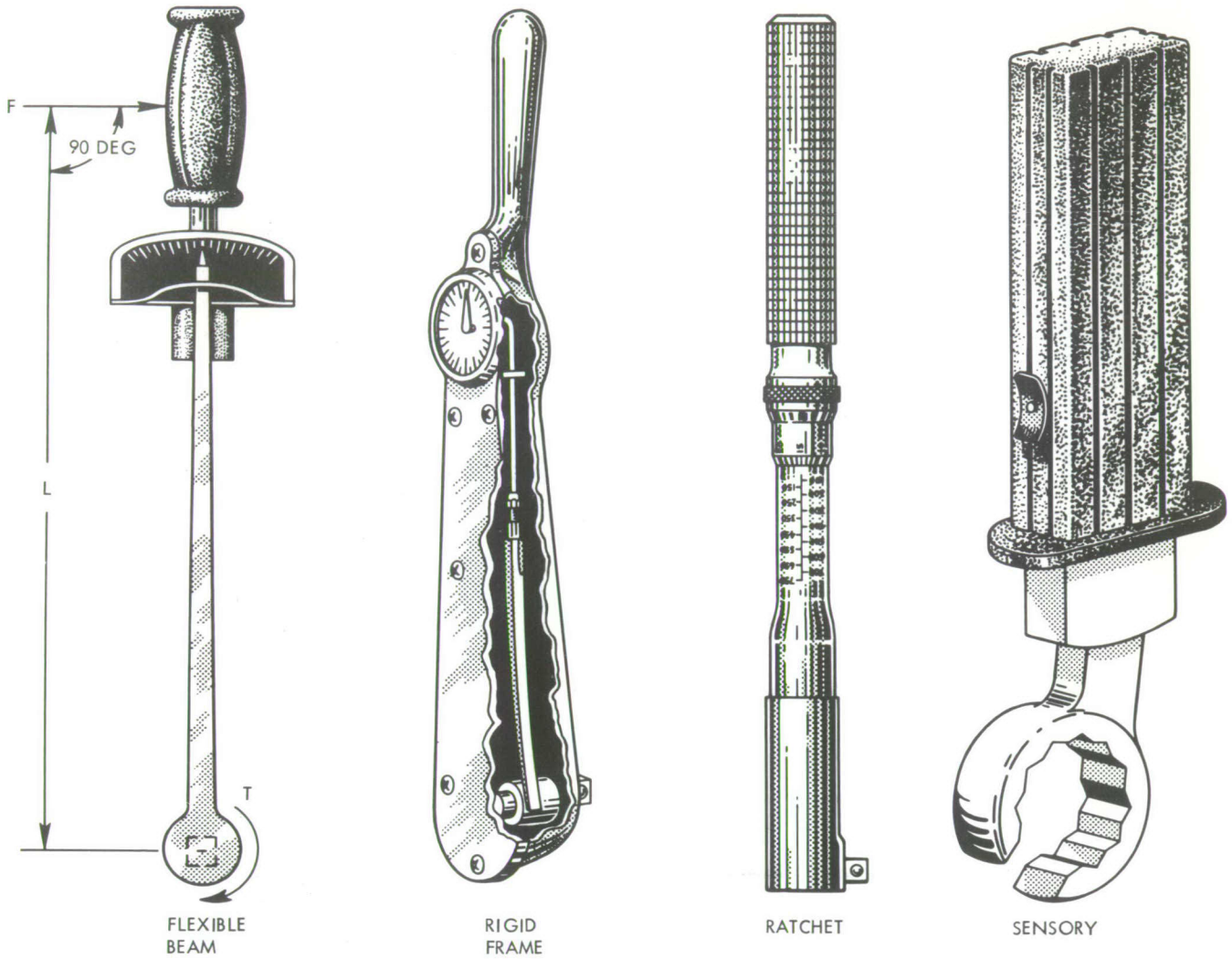


Place retaining rope hook in existing hole located in forward frame of step.

ATTACH POINT AT STEP

Caution The area in front of the air inlet duct should be swept clean to minimize the possibility of dirt or other objects being drawn into the compressor and damaging the engine.

Figure No. 5-4. Ground Run-up Danger Areas

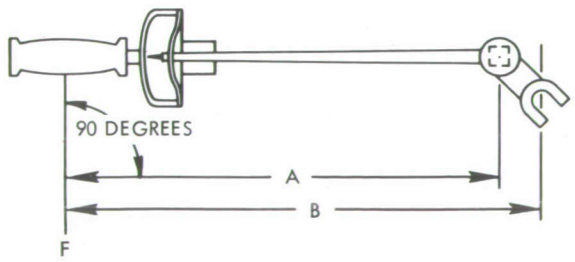


Basic formula F x L = T

F = Applied force

L = Lever length between centerline of drive and centerline of applied force (F must be 90 degrees to L)

T = Torque



Formula for use with extensions $Tw = \frac{Te \times A}{B}$

A = Lever length of wrench

B = Lever length of wrench plus extension

Te = Required torque on bolt

Tw = Torque reading on wrench dial

Note It is not advisable to use a handle extension on a flexible beam type torque wrench at any time. A handle extension alone has no effect on the reading of the other types. The use of a drive end extension on any type of torque wrench makes the use of the formula mandatory. When applying the formula, force must be applied to the handle of the torque wrench at the point from which the measurements were taken. If this is not done, the torque obtained will be in error.

FJ-4B-2-00-5

Figure No. 5-5. Effects of Adapters on Torque Wrenches

THE FOLLOWING LIST IS A LIMITED PRESENTATION OF THE MOST COMMONLY USED BOLTS AND SCREWS. THIS LIST CAN BE USED IN CONJUNCTION WITH THE TORQUE TABLE TO COMPUTE THE TORQUE ON STANDARD PARTS.

PART NUMBER	DESCRIPTION	PART NUMBER	DESCRIPTION
AN3 THRU AN20	HEX HEAD BOLT. DRILLED OR PLAIN HEAD OR SHANK.	AN23 THRU AN36	CLEVIS BOLT.
AN73THRU AN76	HEX HEAD BOLT. MULTIPLE DRILLED. FINE OR COARSE THREAD.	AN173 THRU AN186	HEX HEAD BOLT. CLOSE TOLERANCE.
AN500 AND AN501	FILLISTER HEAD SCREW.	AN502 AND AN503	FILLISTER HEAD SCREW. HIGH-STRENGTH.
AN507	FLUSH HEAD SCREW. CARBON STEEL.	AN509	FLUSH HEAD SCREW. HIGH-STRENGTH STEEL.
AN515 AND AN520	ROUND HEAD SCREW. CARBON STEEL.	AN526	TRUSS HEAD SCREW. CARBON STEEL.
MS20004	INTERNAL WRENCHING BOLT. 160,000 PSI.	NAS464	HEX HEAD BOLT. CLOSE TOLERANCE. EXTRA HIGH-STRENGTH. SHEAR.
NAS333 THRU NAS340	FLUSH HEAD BOLT. CLOSE TOLERANCE. EXTRA HIGH-STRENGTH.	NAS220 THRU NAS226	BRAZIER HEAD SCREW. HIGH-STRENGTH. STEEL OR BRONZE.
NAS501	HEX HEAD BOLT. STABILIZED, NON-MAGNETIC, CORROSION-RESISTANT STEEL.	5B25	HEX HEAD BOLT. CORROSION-RESISTANT STEEL. HIGH-STRENGTH FOR HIGH TEMPERATURE AND NONMAGNETIC INSTALLATIONS.
5B26	HEX HEAD BOLT. INCONEL "X." HIGH-STRENGTH FOR HIGH TEMPERATURE AND NONMAGNETIC INSTALLATIONS.	5B29	EXTERNAL WRENCHING BOLT. HIGH-STRENGTH.
5B30	HEX HEAD BOLT. A-286 CORROSION- AND HEAT-RESISTANT STEEL. HIGH-STRENGTH FOR HIGH TEMPERATURE AND NONMAGNETIC INSTALLATIONS.	7S13	FLUSH HEAD SCREW. CORROSION-RESISTANT STEEL. SHORT THREAD.
7S14	FLUSH HEAD SCREW. CORROSION-RESISTANT STEEL. SHORT THREAD.	7S16	FLUSH HEAD SCREW. CORROSION-RESISTANT STEEL. LONG THREAD.
7S21	FLUSH HEAD SCREW. CORROSION-RESISTANT STEEL.	7S22	FLUSH HEAD SCREW. INCONEL "X." HIGH-STRENGTH FOR HIGH TEMPERATURE AND NONMAGNETIC INSTALLATIONS.
7S27	HEX HEAD BOLT. A-286 CORROSION AND HEAT RESISTANT STEEL. HIGH-STRENGTH FOR HIGH TEMPERATURE AND NONMAGNETIC INSTALLATIONS.	7S28	100-DEGREE CLOSE TOLERANCE SCREW. 105,000 PSI MINIMUM SHEAR STRENGTH.

Note The torque on special bolts and screws cannot be computed from the torque table. All nonstandard torque values are called out in this handbook in the installation procedure for the part involved.

FJ-4B-2-00-6

Figure No. 5-6. Standard Torque Table (Sheet 1)

BOLTHEAD MARKINGS			
MARKING	DEFINITION	MARKING	DEFINITION
X 	STEEL BOLT		CLOSE TOLERANCE BOLT
 "SPL" OR PART NUMBER	SPECIAL BOLT		STANDARD BOLT REWORKED TO SPECIAL CONFIGURATION

BOLT, STUD, OR SCREW SIZE	TORQUE VALUES IN INCH-OUNCES FOR TIGHTENING NUTS			
	ON STANDARD BOLTS, NUTS, AND SCREWS HAVING A TENSILE STRENGTH OF 40,000 TO 60,000 PSI		ON HIGH STRENGTH BOLTS, STUDS, AND SCREWS HAVING A TENSILE STRENGTH OF 90,000 PSI AND OVER	
	SHEAR TYPE NUTS	TENSION TYPE NUTS AND THREADED MACHINE PARTS	SHEAR TYPE NUTS	TENSION TYPE NUTS AND THREADED MACHINE PARTS
0 - 80	5.0 - 7.5	8.5 - 13.0	7.5 - 11.5	13.0 - 19.0
1 - 64	9.0 - 13.5	15.0 - 22.5	13.5 - 20.0	22.5 - 33.5
1 - 72	10.0 - 15.0	17.0 - 25.5	15.5 - 23.0	25.5 - 38.5
2 - 56	15.0 - 22.0	24.5 - 37.0	22.0 - 33.0	37.0 - 55.0
2 - 64	16.5 - 25.0	28.0 - 41.5	25.0 - 37.5	42.0 - 62.5
3 - 48	21.0 - 31.5	35.5 - 53.0	32.0 - 47.5	53.0 - 79.0
3 - 56	24.0 - 35.3	39.5 - 59.0	35.5 - 53.5	59.5 - 89.0
4 - 40	31.0 - 46.0	51.5 - 77.0	46.5 - 69.0	77.0 - 115.0
4 - 48	36.0 - 53.5	60.0 - 89.5	54.0 - 80.5	90.0 - 134.5
6 - 32	58.5 - 87.5	97.5 - 145.5	88.0 - 131.0	146.5 - 218.5
6 - 40	71.5 - 106.5	119.0 - 177.5	107.0 - 160.0	178.5 - 266.5

FJ-4B-2-00-7

Figure No. 5-6. Standard Torque Table (Sheet 2)

BOLT, STUD, OR SCREW SIZE		TORQUE VALUES IN INCH-POUNDS FOR TIGHTENING NUTS			
		ON STANDARD BOLTS, STUDS AND SCREWS HAVING A TENSILE STRENGTH OF 125,000 TO 140,000 PSI		ON BOLTS, STUDS AND SCREWS HAVING A TENSILE STRENGTH OF 140,000 TO 160,000 PSI	ON HIGH STRENGTH BOLTS, STUDS AND SCREWS HAVING A TENSILE STRENGTH OF 160,000 PSI AND OVER
		SHEAR TYPE NUTS (AN320, AN364 OR EQUIVALENT)	TENSION TYPE NUTS AND THREADED MACHINE PARTS (AN310, AN365 OR EQUIVALENT)	ANY NUT, EXCEPT SHEAR-TYPE	ANY NUT, EXCEPT SHEAR-TYPE
8 - 32	8 - 36	7 - 9	12 - 15	14 - 17	15 - 18
10 - 24	10 - 32	12 - 15	20 - 25	23 - 30	25 - 35
1/4 - 20		25 - 30	40 - 50	45 - 59	50 - 68
	1/4 - 28	30 - 40	50 - 70	60 - 80	70 - 90
5/16 - 18		48 - 55	80 - 90	85 - 117	90 - 144
	5/16 - 24	60 - 85	100 - 140	120 - 172	140 - 203
3/8 - 16		95 - 110	160 - 185	173 - 217	185 - 248
	3/8 - 24	95 - 110	160 - 190	175 - 271	190 - 351
7/16 - 14		140 - 155	235 - 255	245 - 342	255 - 428
	7/16 - 20	270 - 300	450 - 500	475 - 628	500 - 756
1/2 - 13		240 - 290	400 - 480	440 - 636	480 - 792
	1/2 - 20	290 - 410	480 - 690	585 - 840	690 - 990
9/16 - 12		300 - 420	500 - 700	600 - 845	700 - 990
	9/16 - 18	480 - 600	800 - 1,000	900 - 1,200	1,000 - 1,440
5/8 - 11		420 - 540	700 - 900	800 - 1,125	900 - 1,350
	5/8 - 18	660 - 780	1,100 - 1,300	1,200 - 1,730	1,300 - 2,160
3/4 - 10		700 - 950	1,150 - 1,600	1,380 - 1925	1,600 - 2,250
	3/4 - 16	1,300 - 1,500	2,300 - 2,500	2,400 - 3,500	2,500 - 4,500
7/8 - 9		1,300 - 1,800	2,200 - 3,000	2,600 - 3,570	3,000 - 4,140
	7/8 - 14	1,500 - 1,800	2,500 - 3,000	2,750 - 4,650	3,000 - 6,300
1 - 8		2,200 - 3,000	3,700 - 5,000	4,350 - 5,920	5,000 - 6,840
	1 - 14	2,200 - 3,300	3,700 - 5,500	4,600 - 7,250	5,500 - 9,000
1-1/8 - 8		3,300 - 4,000	5,500 - 6,500	6,000 - 8,650	6,500 - 10,800
	1-1/8 - 12	3,000 - 4,200	5,000 - 7,000	6,000 - 10,250	7,000 - 13,500
		4,000 - 5,000	6,500 - 8,000	7,250 - 11,000	8,000 - 14,000
1-1/4 - 8	1-1/4 - 12	5,400 - 6,600	9,000 - 11,000	10,000 - 16,750	11,000 - 22,500

FJ-48-2-00-15

Figure No. 5-6. Standard Torque Table (Sheet 3)

TEST POINT TROUBLE SHOOTING.

To ease and expedite electrical maintenance, test point trouble shooting data has been incorporated in system trouble isolation procedures and system wiring diagrams. As any system failure or malfunction may result from any one or a combination of electrical, hydraulic, pneumatic or mechanical reasons, all probable causes (reasons) for a stated trouble are covered in the same trouble isolation chart. There are three types of test points: major, secondary and minor. Textual references to these test points are made within each system trouble shooting paragraph and the specific location of each test point may be determined by referring to the appropriate system wiring diagram in Section X. No test point designation will be duplicated nor will more than one test point designation be given to any test point.

MAJOR TEST POINTS.

Major test points are used to isolate a power system failure to a physical portion of the airplane or to a group of systems. Major test points are symbolized on system wiring diagrams by a star encircled Arabic numeral. Major test points are referred to in text as: test point 1, test point 2, etc. Some examples of major test points are: generator and inverter outputs, power distribution connections, etc.

SECONDARY TEST POINTS.

Secondary test points are used to isolate failure to a specific system or to a specific item within a system. Secondary test points are symbolized on system wiring diagrams by an encircled capital letter(s). The letters "I" and "O" are not used to avoid confusion with the numerals one and zero. Secondary test points are referred to in text as: test point A, test point AB, etc. Some examples of secondary test points are: power inputs to individual units, tie-ins with parallel or interrelated systems, sequence switches, etc. Secondary test points for any specific system will always have as their initial identifying letter the same letter as the initial letter of the wire numbers of that system.

MINOR TEST POINTS.

Minor test points are used to isolate failure within a unit. Minor test points are symbolized on system wiring diagrams by an encircled capital letter and Arabic numeral. The letters "I" and "O" are not used to avoid confusion with the numerals one and zero. Minor test points are referred to in text as: test point A1, test point A2, etc. Some examples of minor test points are: continuity through a switch or a relay that is part of a unit, resistance readings of items within a unit, etc. Minor test points for any specific system will always have as their initial identifying letter the same letter as the initial letter of the wire numbers of that system.

USE OF TROUBLE SHOOTING CHARTS.

The best trouble shooting aid is preventive maintenance and cleanliness. The next best trouble shooting aid is thorough knowledge of the theory and operation of the system in question. A thorough knowledge of the system permits rapid determination of the most likely probable cause for any given trouble and thereby reduces trouble shooting time and effort. The third most important aid is safety; observe all safety rules, check to make sure that the airplane and any attached ground power equipment is properly grounded, check to make sure that all ground safeties are installed, follow the trouble shooting instructions and if it is a two-man job, get another man to help. What is the trouble? Check the squawks, observe or perform an operational or functional check of the system in question. Check the trouble shooting charts of the system for the determined trouble. Select the most probable cause(s) and proceed to isolate the trouble; set up the system as specified in the "System Conditions" portion of the chart. Use the appropriate meters. Do not make ohmmeter tests or continuity checks on an electrically "hot" airplane. Complete check-out of the system in question without correction of the trouble may indicate that a parallel or interrelated system is at fault. If so, refer to that system for appropriate trouble shooting information. When a remedy is performed that does not correct the trouble, select the next most probable cause and continue trouble shooting. Isolation procedures are set up to require a minimum of effort. Each procedure should either isolate the trouble itself or isolate the portion of the circuit that contains the trouble. When a test point procedure is called out for an item (for example, a valve solenoid), parts of that procedure not spelled out which may lead to isolating the fault are: visual inspection for signs of physical damage, check of the ground connection or bonding and a check for good electrical connections. Similarly, when test points are called out for relay terminals, the switch section of the relay involved should be checked for proper action and continuity. The various portions of the trouble shooting charts and their functions are as follows:

a. TEST EQUIPMENT. This portion of the charts contains a list of all test equipment that will be required to perform any isolation procedure that follows on the same chart.

b. SYSTEM CONDITIONS. This portion of the charts specifies the desired system conditions for the tests that will follow. Some isolation procedures may require a change to these conditions; if so, the new conditions will be given in note form.

c. TROUBLE. This is the observed symptom, malfunction or fault.

d. PROBABLE CAUSE. The probable cause(s) states the condition or reason causing the trouble. Probable causes are listed in their most likely order. The probable causes may be electrical, mechanical, hydraulic, pneumatic, etc, or a combination of these reasons.

e. ISOLATION PROCEDURE. This portion of the charts is a positive statement of action. If the probable cause is nonelectrical, there will be no mention of test points; if electrical, specific directions related to one or more test points will be given. Isolation procedures are listed in their most likely or accessible order. What meter is to be used will be determined by the required

meter reading(s). Use the appropriate system wiring diagram in Section X to locate test points and to perform wire segment continuity checks. Many isolation procedures require the use of test points located at a connector. In such cases, it is necessary to disengage the connector and to apply the test probe to the plug or receptacle portion of the connector as shown on the system wiring diagram. Connectors should never be disengaged with electrical power applied to the airplane. Do not damage connector sockets by inserting test probes.

f. METER READINGS. If the isolation procedure is nonelectrical, this portion of the chart will indicate that none is required. If test points have been specified in the isolation procedure, the value and type of reading will be stated. Resistance and voltage readings are the type most commonly required for the isolation procedures; values given will indicate their type and the corresponding type of meter should be used to obtain the reading.

g. REMEDY. For nonelectrical isolation procedures, the remedy will indicate the maintenance action required depending upon the results of the isolation procedure. For electrical isolation procedures, the remedy will indicate the maintenance action required for the meter reading obtained. Most remedies will indicate a definite maintenance action, but some remedies will indicate that further isolation procedures should be performed. Some meter readings will indicate that the airplane wiring is at fault (open or shorted) and the remedy will be to perform a wire segment continuity check. Such continuity checks should be performed so as to minimize effort. Remove power and disconnect wires as necessary; then, check for continuity at the most accessible mid-point of the circuit; in this manner, several wire segments can be checked for continuity at one time.

WARNING

Never disconnect wires or disengage disconnects with electrical power applied to the airplane. Always ground the airplane and any attached ground power equipment.

Note

Secondary test points are listed alphabetically and opposite to each applicable wiring diagram title. Figure numbers of the wiring diagrams listed can be found in the Wiring Diagram Index of Section X, in this handbook. Major test points, not listed, can be found in the Starting and D-C Generating System, the D-C Power Distribution System and the A-C Power Supply and Distribution System wiring diagrams. Minor test points, also not listed, can be found by associating them with similar secondary test points.

TEST POINTS	WIRING DIAGRAM TITLE
K, KA—KZ	Starting and D-C Generating System (Engine starting)
PA—PZ	Starting and D-C Generating System (D-C power supply)
QMA—QMZ	Manual Fuel Control

CONSUMABLE MATERIALS

ITEM NO.	NOMENCLATURE	SPECIFICATION OR STOCK NO.	MANUFACTURER	SUBSTITUTE
3	Adhesive, Rubber (EC-870)	MIL-A-1154; Stock No. G8040-273-8717	Minnesota Mining and Manufacturing Co.	
8	Anti-seize Compound, Fel-Pro C-5	Stock No. R52C3265700		
61	Grease, Aircraft and Instrument (For Low and High Temperatures)	MIL-G-3278; Stock No. WS9150-261-8297		
80	Lubricant, Molybdenum Disulfide	MIL-M-7866; Stock No. W6810-227-0431		
87	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base	MIL-L-7808; Stock No. WS9150-227-0184		
95	Oil, Hydraulic, Aircraft, Petroleum Base	MIL-O-5606; Stock No. WR9150-223-4134		
100	Petrolatum, Technical	VV-P-236; Stock No. WS9150-250-0926		
127	Tape, Glass Cloth, Pressure-sensitive, Flame-proof	MIL-P-4053		

ENGINE

5-1. ENGINE.

Note

For service and maintenance instructions on the J65-W-4B and J65-W-16A engines which are not included in this handbook, refer to the Handbook of Service Instructions (AN 02B-35AAC-2).

5-2. There are two engines currently in use in the FJ-4B airplane, the J65-W-4B and the J65-W-16A. Air is delivered through an annular intake at the front of the engine into a multi-stage, axial flow compressor. After compression, the air passes into an annular combustion chamber where the air combines with the fuel for combustion. Partial expansion of the gases through a two-stage turbine produces mechanical power which drives the compressor; continued expansion of the gases in an exhaust duct at the rear of the engine produces a high velocity jet exhaust which propels the airplane. The engine has a static thrust rating of 7700 pounds with a maximum speed of 8300 rpm. The engine is divided into the front main bearing support, the compressor section, the center main bearing support, the annular combustion chamber, the rear main bearing support, the turbine section and the exhaust section. The engine is supported in the airplane at three points: the left- and right-hand sides are supported by trunnion mounts at the mid-point of the engine, and the front of the engine is supported by a forward steady support. The steady support rolls in a guide rail at the top of the fuselage when the engine is being removed or installed. The two side mounts transmit the engine loads to the fuselage. For further information on the engine trunnions and their adjustment, see figure 5-7. Two bevel gear boxes are mounted on the front main bearing support; one gear box is driven through strut No. 4 and provides the drive for the No. 1 flight control hydraulic pump; the other gear box is driven through strut No. 2. A power take-off drive from this gear box drives the accessory gear box mounted on the compressor housing. The engine accessories driven by the accessory gear box are the dual gear-type fuel pump, the fuel control unit, the scavenge oil pump, the tachometer generator, the magneto generator, the No. 2 flight control hydraulic pump and the utility hydraulic pump. The starter-generator is driven by a starter drive on the front center section of the engine. Other components mounted on the engine are the primer valve solenoid, the fuel flowmeter transmitter and the oil pressure switch. Refer to paragraph 5-5 for location of the various components and accessories. Access to the various sections of the engine for purposes of inspection and maintenance may be gained through the left- and right-hand engine access doors, the engine access door on the bottom of the fuselage forward of the fuselage break and the left- and right-hand wheel well access doors. A small door is located on the surface of the engine access door on the bottom of the fuselage. This door provides access to the external power receptacles. A transverse bulkhead separates the engine from the cockpit. A fireproof flexible bulb seal forms a seal with the fixed fuselage fire wall and divides the engine compartment into two compartments: the relatively cool forward compartment and the hot aft compartment. This prevents the leakage of combustible liquids or fumes coming in contact with the hot aft portions of the engine or coming in direct contact with the exhaust gases. To reduce heat radiation, the tail-pipe and engine exhaust cones are wrapped with heat insulation blankets. To further protect the fuselage structure and maintain safe structure temperatures, each compartment has a separate ventilating airflow system. The forward compartment is cooled during flight by air which enters through a continuous 1/4-inch opening around the engine air inlet. This air circulates over the engine and is expelled overboard through six outlet ducts located in the top, the bottom and the right- and left-hand sides of the fuselage. During ground operation, the reverse condition exists: the cooling air enters the forward compartment through the normal outlet ducts and is drawn through the 1/4-inch opening into the engine compressor. The aft compartment is cooled by air entering two inlet ducts, one located on each upper side of the fuselage, just forward of the speed brakes. This air passes along the inner surface of the fuselage to maintain the temperature of the fuselage structure within safe operating limits and is expelled overboard by the aspirator action of the exhaust jet stream through the annular opening formed by the exhaust tail-pipe nozzle and the rear of the fuselage.

5-3. TROUBLE SHOOTING ENGINE.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
COMBUSTION DOES NOT OCCUR DURING AN ATTEMPTED START.		
Improper starting procedure.		Refer to paragraph 5-16 for correct starting procedure.
Faulty ignition system.	Perform trouble isolation procedure check as outlined in paragraph 5-98.	Replace defective parts or components.
Faulty fuel control unit.		Replace fuel control unit.
Fuel pump not functioning properly.		Replace fuel pump.
Fuel shutoff valve not open.		Correct or replace valve.
Engine fuel filter dirty or clogged.	Remove and inspect filter.	Clean and replace filter.
Fuel primer solenoid valve not functioning properly.		Replace valve.
Fuel primer nozzle clogged.	Examine nozzles.	Clean or replace nozzles if necessary and check fuel system for possible contamination.
INSUFFICIENT OR NO RPM WHEN ATTEMPTING TO START ENGINE.		
If power from external source is satisfactory, yet starter motor is straining to turn engine rotor, the trouble is mechanical and is probably caused by:		
a. Icing in compressor.		Direct hot air into compressor inlet.
b. Shroud ring seizure.		Allow engine to cool, provided seizure was caused by too sudden shutdown of engine at previous operation. When checking after cooling, turn turbine with wooden pole or with an external air pressure source through compressor. If shroud ring still rubs, remove tail pipe and exhaust cone to check bucket tip clearance. Replace shroud ring after making sure that any recently replaced bucket is not too long.
c. Starter shaft sheared.		Replace starter and check auxiliary power unit for malfunction.
d. Compressor or other type of seizure.		Make an extensive investigation and replace engine if necessary.
If compressor rotor turns freely, trouble can be assumed to be electrical as follows:		
a. Starter-generator leads reversed.	Remove starter-generator cover and check leads. Refer to paragraph 5-5 for correct routing of leads.	Put leads in correct position if reversed.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
INSUFFICIENT OR NO RPM WHEN ATTEMPTING TO START ENGINE. (Cont)		
b. Faulty external power source or connections.	Check external power source for proper output and proper connections.	Replace external power source if defective.
c. Worn or defective starter-generator brushes or commutator.	Measurement from top of brush box to top of brush clip must be less than 3/8 inch.	Replace starter-generator. (Refer to paragraph 5-86.)
d. Starter system not functioning properly.	Perform trouble isolation procedure check as outlined in paragraph 5-82.	Replace defective parts or components.
Starter does not rotate.	Remove starter-generator cover and check leads and terminals.	One or more leads grounded to starter case or shroud. File end of lead to remove excess metal and reinstall lead.
ENGINE ROTATES WHEN STARTER SWITCH IS ENERGIZED BUT STOPS WHEN SWITCH IS RELEASED.		
Starter switch or starter-controller defective.	Perform trouble isolation procedure check as outlined in paragraph 5-82.	Replace defective switch or starter-controller.
Main electrical connector faulty.	Check contact pins and continuity.	Replace connector if defective.
ENGINE UNABLE TO REACH 100% RPM WITH FULL POWER SETTING.		
Tachometer indicator reading faulty.	Check operation of tachometer indicator and tachometer generator.	Replace defective component.
Air trapped in fuel control unit.		Bleed fuel control unit. (Refer to paragraph 5-51.)
Fuel flow dividers not functioning properly.		Replace faulty fuel distributors.
Engine fuel pump not operating properly.	Check pump. (Refer to paragraph 5-54.)	Replace engine fuel pump.
Engine fuel filter clogged.	Check filter.	Clean or replace filter.
Engine controls not properly adjusted.		Adjust engine control system. (Refer to paragraph 5-41.)
Airflow restricted.	Check air inlet duct for evidence of foreign material.	Remove foreign material.
Engine fuel control unit not set correctly.	Check settings. (Refer to paragraph 5-41.)	Adjust setting on engine fuel control unit high-speed stop.
ENGINE EXCEEDS 100% RPM AT FULL THROTTLE POSITION.		
Tachometer indicator reading faulty.	Check operation of tachometer indicator and tachometer generator.	Replace defective component.
Engine power control unit not set correctly.		Adjust setting on engine fuel control unit high-speed stop.
Engine operating on manual fuel control.	Check position of fuel selector switch.	Reposition switch.

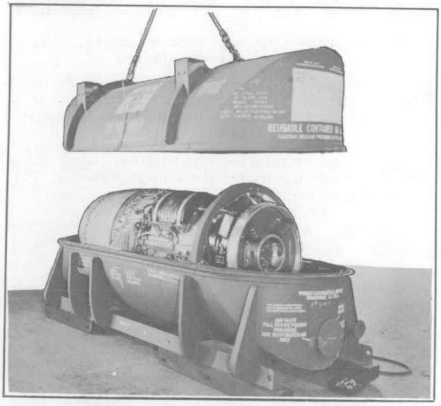
PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
ENGINE SURGES OR HUNTS WITH FIXED THROTTLE SETTING.		
Engine fuel filter clogged.		Clean or replace filter and check fuel filter for possible contamination.
Tachometer generator malfunctioning.	Refer to paragraph 6-279 for functional check.	Replace tachometer generator.
Faulty fuel control unit.		Replace control.
HOT START.		
Improper starting procedure.		Refer to paragraph 5-16.
Faulty auxiliary power unit.	Check output of external power source.	Correct or replace auxiliary power unit.
Faulty ignition system.	Perform ignition system trouble isolation procedure and ignition system check. (Refer to paragraphs 5-96 and 5-98.)	Replace defective components.
Engine, components or accessories binding.	Make an extensive investigation.	Replace engine if necessary.
Hot section damage.	Perform hot section inspection.	Replace engine if any hot section inspection limits are exceeded.
Restricted airflow.	Check engine air intake duct for evidence of foreign object.	Remove obstruction. Check for foreign object damage.
SMOKE AND/OR OIL FUMES IN THE COCKPIT DURING GROUND RUN-UP.		
Front main bearing oil seal leakage.	If excessive smoke appears in the cockpit during an air or ground check of the heat and vent system, make the following engine oil consumption ground check: a. Fill the oil tank to maximum capacity. (Refer to paragraph 1-36.) b. Start the engine and operate at 90% rpm for 15 minutes. c. Immediately after engine shutdown, check the oil level in the tank. If the oil consumption after the 15-minute ground operation is in excess of 0.125 gallon (1 pint), the trouble is probably front main bearing oil seal leakage.	Replace engine.
ENGINE VIBRATES.		
Faulty engine accessory.	Run engine at speeds at which the vibration was reported and check all accessories for evidence of concentrated vibration.	Replace faulty accessory.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
ENGINE VIBRATES. (Cont)		
Faulty airplane component or system.	Check various airplane components such as wing flaps, speed brake operation, fuel transfer system, etc, for evidence of concentrated vibration.	Repair or replace faulty component.
Foreign object damage to engine.	Inspect compressor for foreign object damage.	Replace engine.
Improperly torqued or worn engine mounts.	Inspect and retorque main engine mounts and forward steady support.	Replace mounts if worn.
Improperly installed or damaged tail pipe.	Check tail pipe for buckling or other damage and retorque tail-pipe clamp.	Replace tail pipe if damage exceeds limits.
Faulty or damaged engine.	Check turbine and turbine shroud for damage, including rubbing and metallization. Check exhaust cone support rods or bolts for wear. Check accessories for proper torque and accessory mounts for wear.	Replace engine or accessories as required.
Improperly torqued aft fuselage bolts.		Retorque as necessary.

5-4. PREPARING ENGINE FOR BUILD-UP.

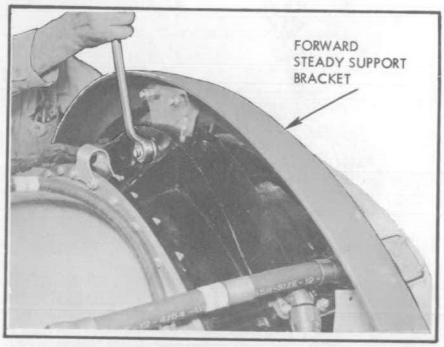
1 Depressurize container through the air fill valve. Remove nuts and bolts securing cover to container. Install a sling in the cover hoist eyes and lift the cover clear of the engine.

2 Remove thermocouple harness from engine. (The harness is wrapped in brown paper.)



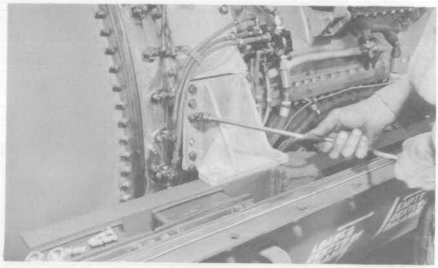
3 Attach sling (E2568) to engine. Raise hoist enough to apply tension to sling. Do not lift engine.

4 Remove bolt from forward steady support bracket.

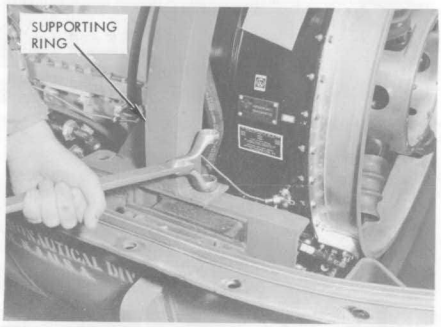


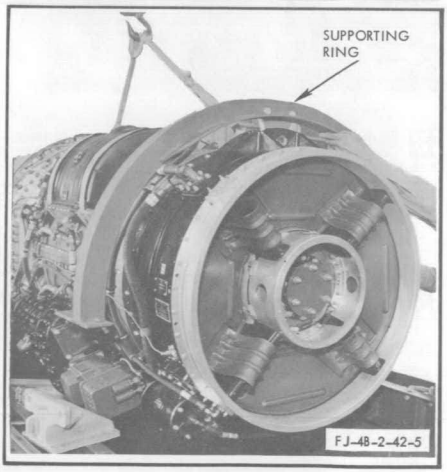
FJ-4B-2-42-4

5 Remove bolts from supporting brackets on trunnion mounts and remove brackets.



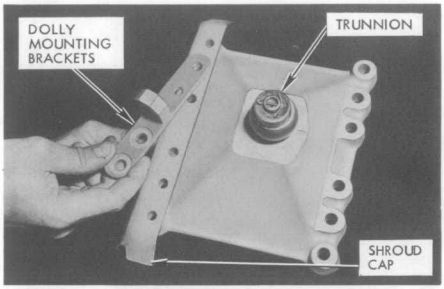
6 Remove bolts from supporting ring on front of engine and remove ring.

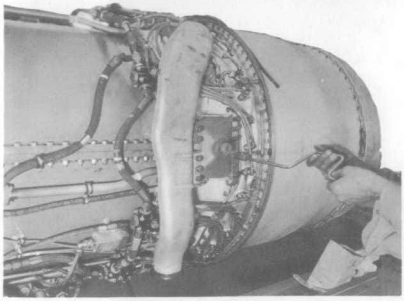




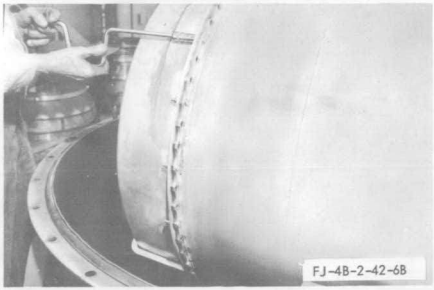
7 Install left- and right-hand trunnions. Trunnion shroud caps and engine dolly mounting brackets are installed with trunnions. Torque bolts from 225 to 250 inch-pounds. Oil vapor overboard duct is installed with trunnion on left-hand side of engine as shown in photograph. Safety-wire bolts using AN995F41 wire.

Note Make sure that the trunnion with the adjustable keyways is installed on the right-hand side of the engine.

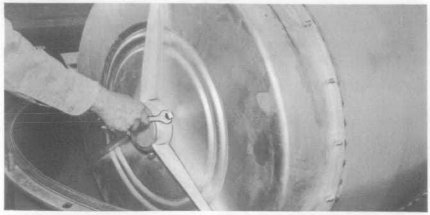




8 Remove bolts securing cover to combustion chamber from flange. Remove bolts from top half of cover before hoisting engine from can.



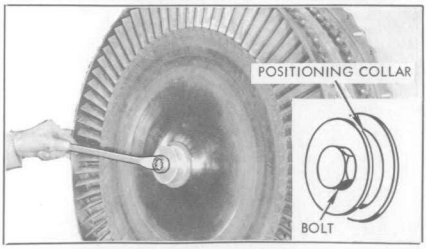
9 Remove bolts from end of cover support.



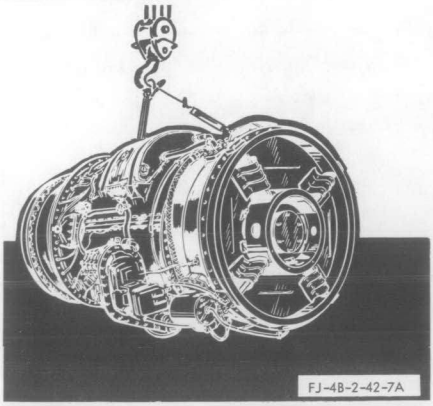
10 Hoist engine from can. Remove remaining bolts from cover flange. Remove cover.

11 Remove positioning collar from shaft at rear of second stage turbine. This positioning collar is used to support rear of cover on engine and is not a part of the engine. Do not reinstall bolt.

Note Inspect turbine rotor plug tablock washer to ensure that the turbine rotor plug was not loosened during the above step.



12 Hoist engine completely from can and place in build-up dolly.



5-5. ENGINE BUILD-UP.

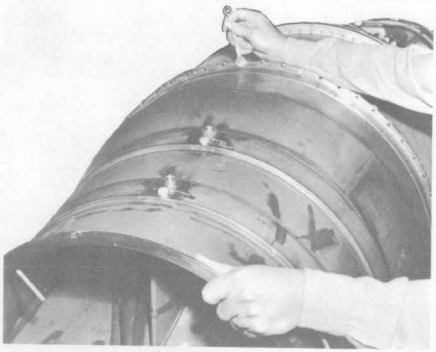
1 PREPARATION FOR ENGINE BUILD-UP.

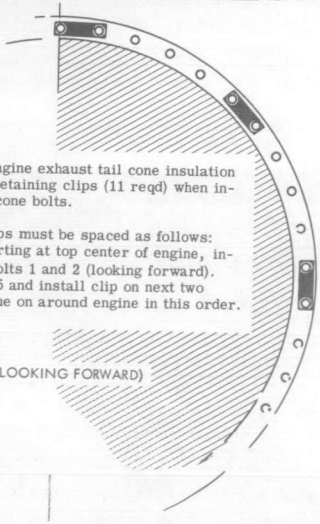
(Refer to paragraph 5-4.)

Note All safety wire used in engine build-up will be AN995N40.

2 INSTALLING ENGINE EXHAUST TAIL CONE.

A. Lift cone into position and secure with a bolt at top.



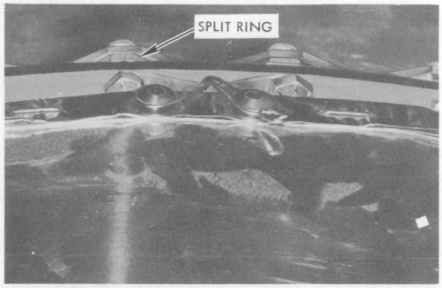


FJ-48-2-42-8

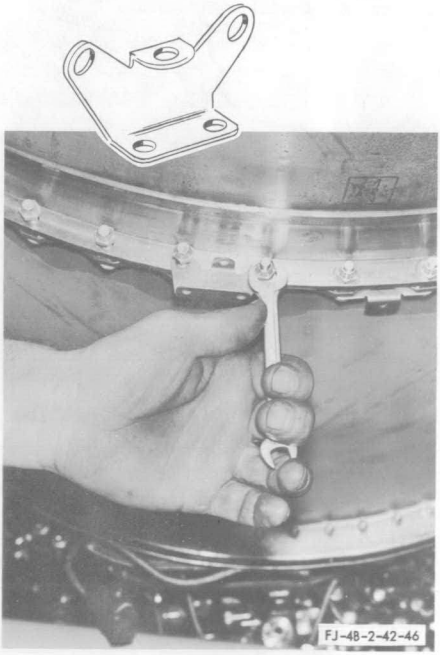
B. Install engine exhaust tail cone insulation blanket retaining clips (11 reqd) when installing cone bolts.

Note Clips must be spaced as follows: Starting at top center of engine, install clip on bolts 1 and 2 (looking forward). Skip 3, 4 and 5 and install clip on next two bolts. Continue on around engine in this order.

C. Before tightening exhaust tailcone attaching bolts, push in on split ring spacer located between the combustion chamber flange and the exhaust tailcone flange. Push in on each side until spacer is closed at top of engine.



D. Install engine combustion chamber fuel drain line support on aft side of flange (bottom centerline of engine).



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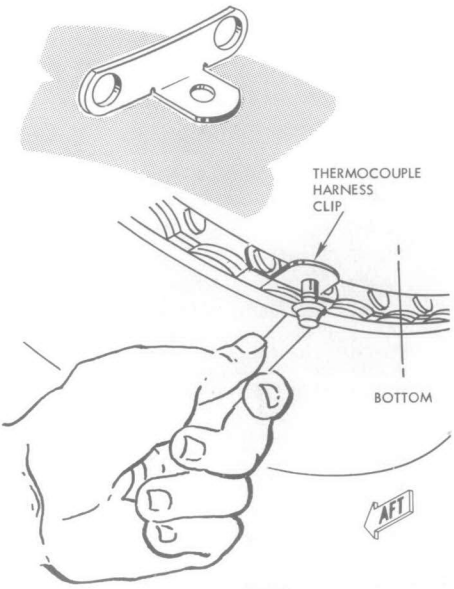
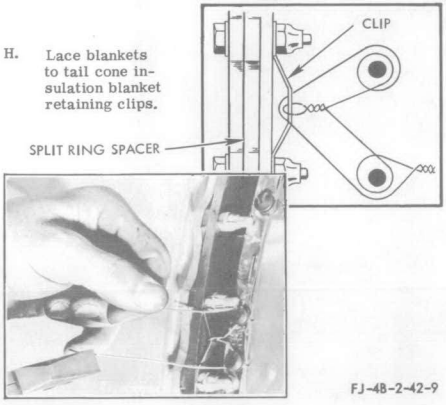
E. Install thermocouple harness clip on forward side of tailcone flange. Use the second and third bolts from the bottom.



F. Install forward sections of engine tailcone insulation blankets.

G. Temporarily fasten ends of blankets with safety wire.

H. Lace blankets to tail cone insulation blanket retaining clips.



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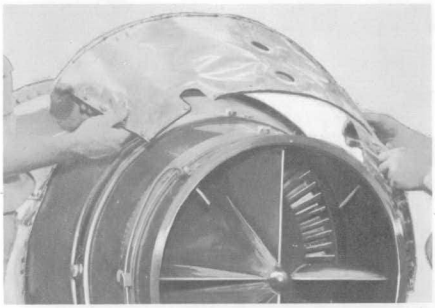
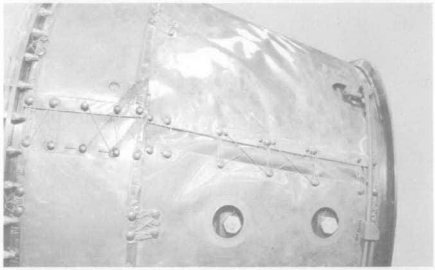
J. Install rear sections of engine exhaust tailcone insulation blankets.

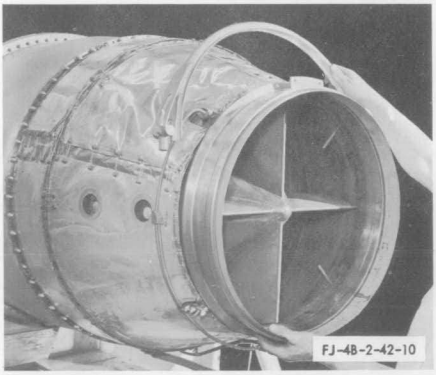


K. Lace front and rear sections of blankets together. (See diagram for lacing procedure.)

L. Lace ends of blankets together as shown.

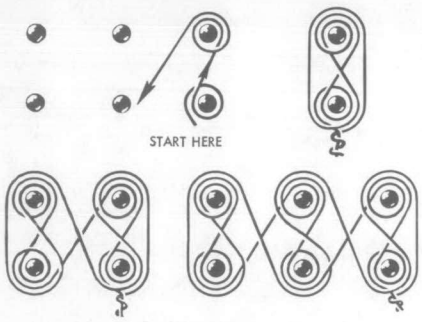


M. Install engine tailcone attaching ring assembly and clamp. Install ring assembly with guide pin at top.



FJ-4B-2-42-10

Lacing procedures used on the tail-pipe insulation blankets shown are for two, four or six buttons.



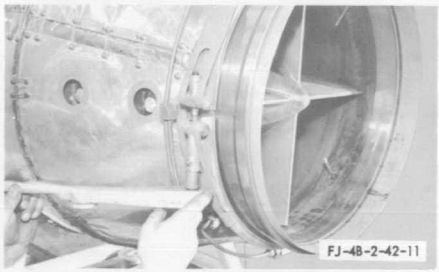
LACING PROCEDURES

Note

- The tail-pipe clamp bolt threads are lubricated using the following mixture: two parts by volume molybdenum disulfide lubricant (item 80, materials list) and three parts by volume oil (item 87, materials list). The oil is added to the molybdenum disulfide and stirred until a homogeneous mixture is obtained. The mixture should be applied to the male thread and may also be applied sparingly to the female thread.

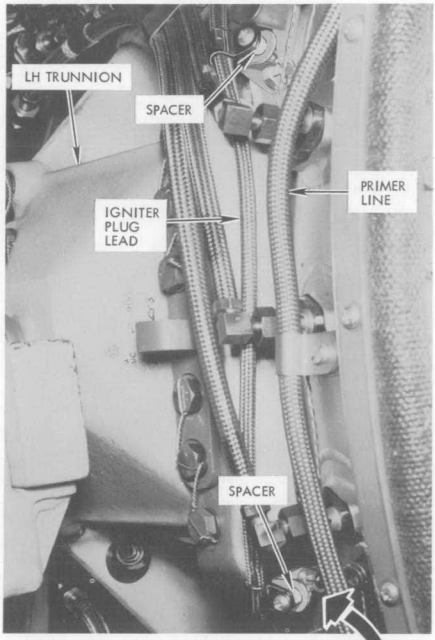
- Do not retighten clamp bolts after engine has been run. Normally, the torque will fall off to approximately zero inch-pounds after a few hours operation. However, the clamp will tighten sufficiently to provide a satisfactory joint during engine operation because of differential thermal expansion of the clamp exhaust cone and pipe. Constant retorquing would subject the clamp to repeated stretching and possible ultimate failure.

N. Torque clamp to 150 inch-pounds, then back off to slightly below 30 inch-pounds and retorque from 35 to 40 inch-pounds. Safety-wire clamp bolts.

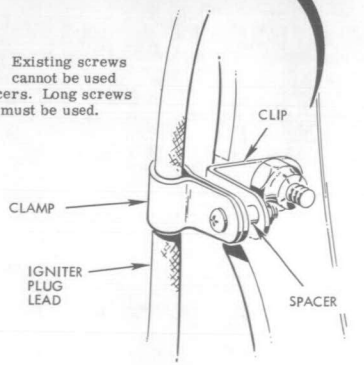


2A INSTALLING SPACERS ON IGNITER PLUG LEAD

A. Remove existing screws from clamps.
B. Install long screws in clamp and position spacer on screw.
C. Insert screw in clip. Install nut and tighten.



Note Existing screws cannot be used with spacers. Long screws from kit must be used.



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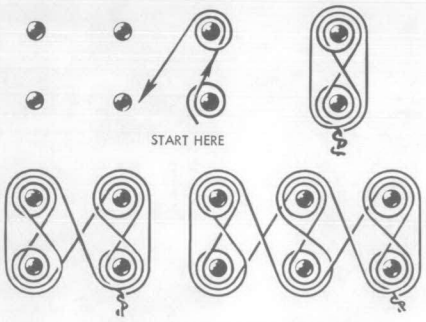
Lacing procedures used on the tail-pipe insulation blankets shown are for two, four or six buttons.



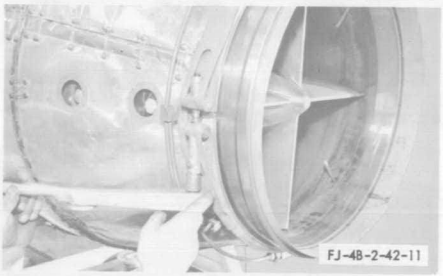
LACING PROCEDURES

Note

- The tail-pipe clamp bolt threads are lubricated using the following mixture: two parts by volume molybdenum disulfide lubricant (item 80, materials list) and three parts by volume oil (item 87, materials list). The oil is added to the molybdenum disulfide and stirred until a homogeneous mixture is obtained. The mixture should be applied to the male thread and may also be applied sparingly to the female thread.

- Do not retighten clamp bolts after engine has been run. Normally, the torque will fall off to approximately zero inch-pounds after a few hours operation. However, the clamp will tighten sufficiently to provide a satisfactory joint during engine operation because of differential thermal expansion of the clamp exhaust cone and pipe. Constant retorquing would subject the clamp to repeated stretching and possible ultimate failure.

N. Torque clamp to 150 inch-pounds, then back off to slightly below 30 inch-pounds and retorque from 35 to 40 inch-pounds. Safety-wire clamp bolts.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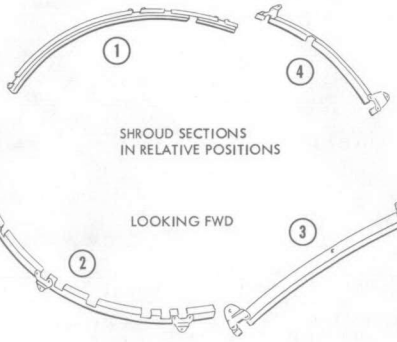
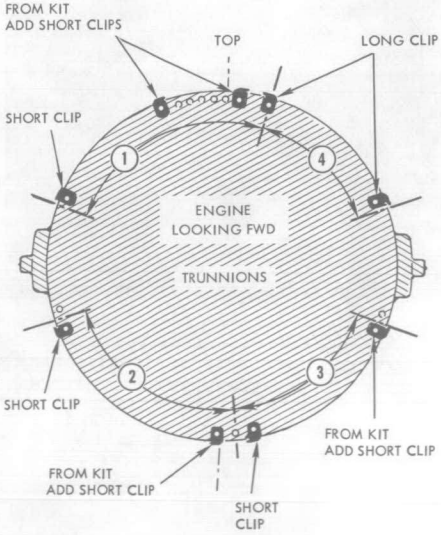
3 INSTALLING SHROUDS.

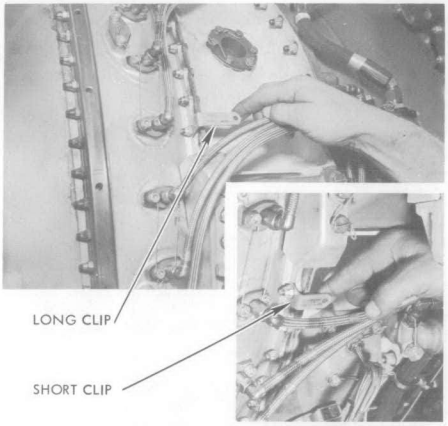
Note Shrouds are referred to by number as shown below.



A. Locate shroud attaching clips shown in diagram. Do not tighten.

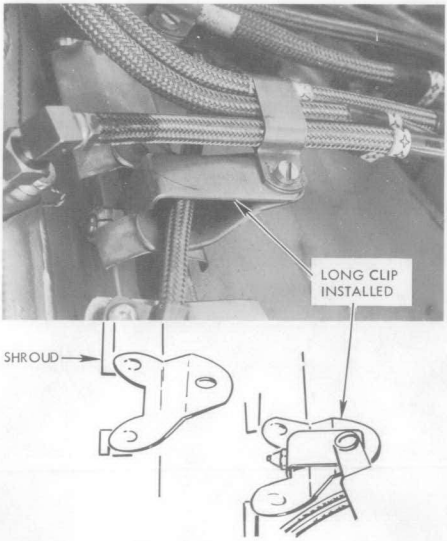


FJ-48-2-42-12



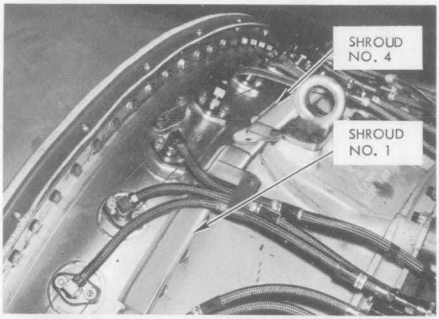
B. Install shroud sections in same order as numbered. In order to install No. 1, the four clips in that area must be removed, then reinstalled. Shrouds 2, 3 and 4, must be slid under the fuel lines into position, then moved aft against the clips.

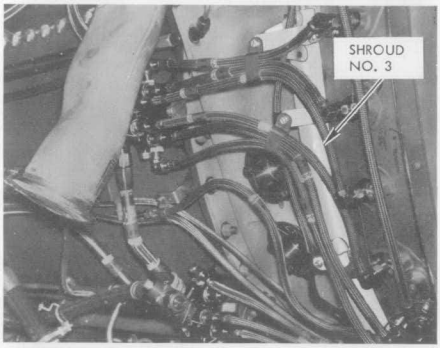
Note Shroud No. 4 overlaps shroud No. 1 at top of engine.

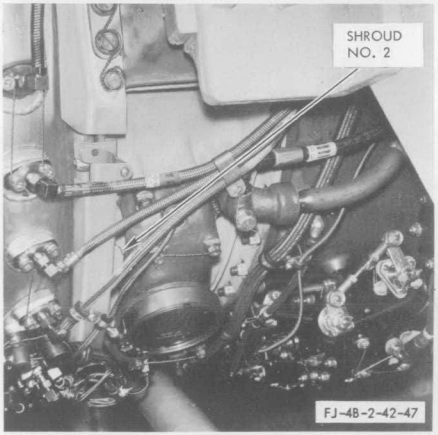


FJ-4B-2-42-13

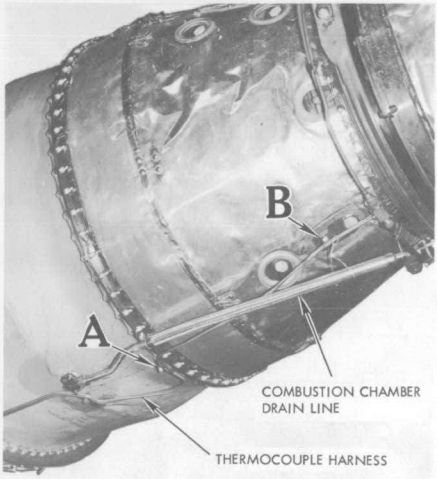
C. After shrouds have been positioned and secured, tighten all bolts.

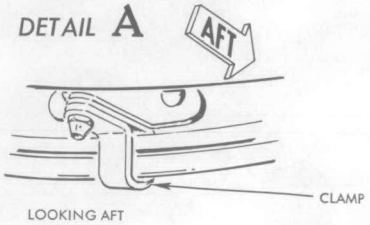


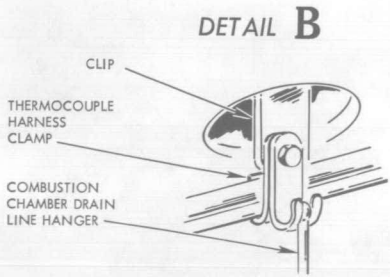




4 INSTALLING THERMOCOUPLE HARNESS AND COMBUSTION CHAMBER DRAIN LINE.





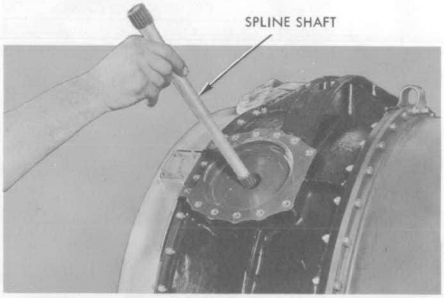


FJ-4B-2-42-14

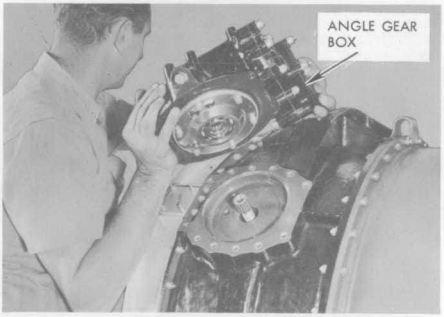
5 ANGLE GEAR BOX AND NO. 1 FLIGHT CONTROL HYDRAULIC PUMP INSTALLATION.

A. Remove mounting pad from No. 4 strut.

B. Insert spline shaft into strut.



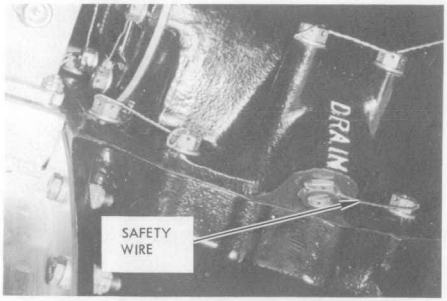
C. Install angle gear box on strut.



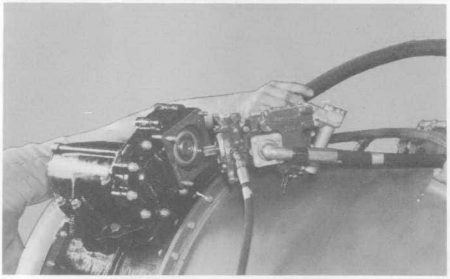
D. Bolt gear box into place. Torque bolts from 108 to 130 inch-pounds.

E. Safety-wire bolts.

F. Install plug and "O" ring and wire plug.



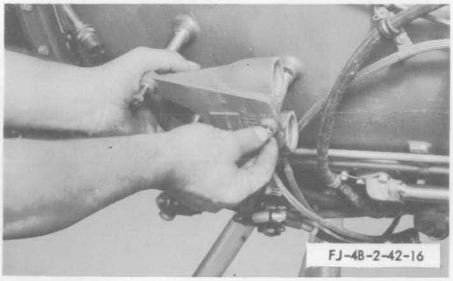
G. Install hydraulic pump.



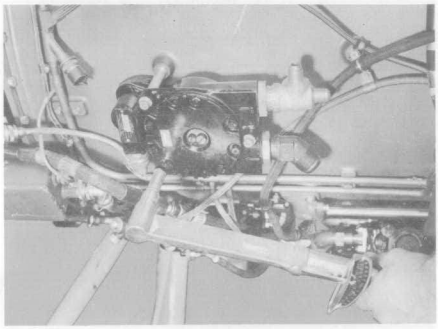
H. Secure hydraulic pump. Torque nuts from 125 to 140 inch-pounds.

6 FUEL FLOWMETER TRANSMITTER INSTALLATION.

A. Remove lines from fuel flowmeter transmitter adapter and remove adapter. Retain fittings for installation of fuel flowmeter transmitter.

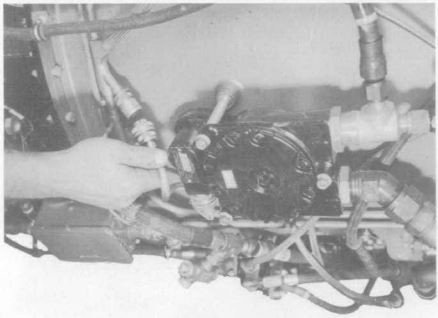


B. Install fuel flowmeter transmitter. Torque retaining bolts from 80 to 85 inch-pounds and install fittings removed from adapter.

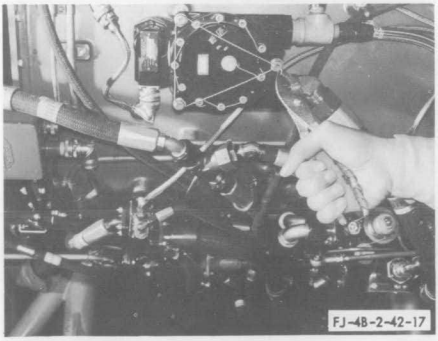


C. Attach lines to fitting and connect electrical lead to engine electrical system.

D. Safety-wire electrical lead.

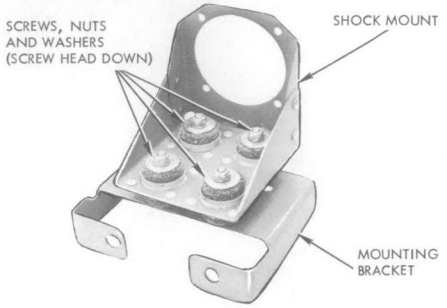


E. Safety-wire fuel flowmeter bolts.

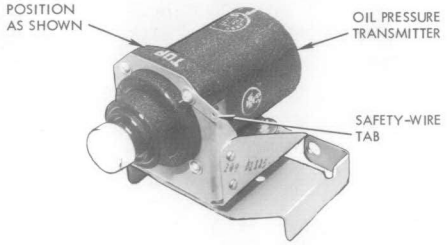


7 A Oil pressure transmitter installation - airplanes 1435431 and subsequent.

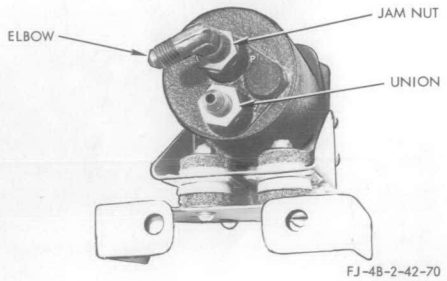
A. Position shock mount on mounting bracket and install with four screws, eight washers and four nuts.



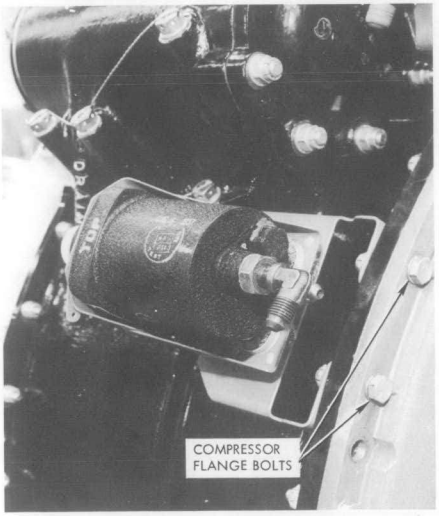
B. Position oil pressure transmitter on shock mount and install with four screws and washers. Install safety-wire tab under head of screw as shown.



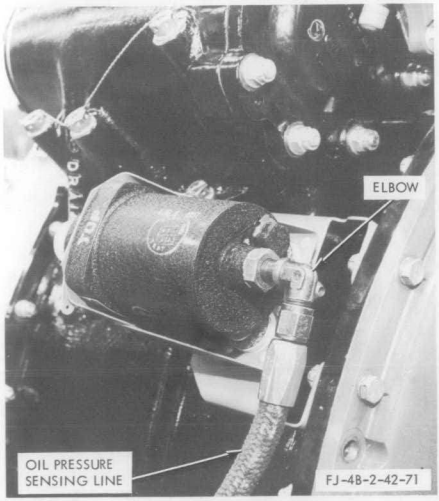
C. Install elbow and "O" ring in oil pressure transmitter pressure port. Do not tighten jam nut on elbow. Install union and "O" ring in oil pressure transmitter vent port.



D. Remove nuts from two bolts on front compressor flange. Place oil pressure transmitter assembly in position and install nuts. Torque nuts from 125 to 140 inch-pounds.



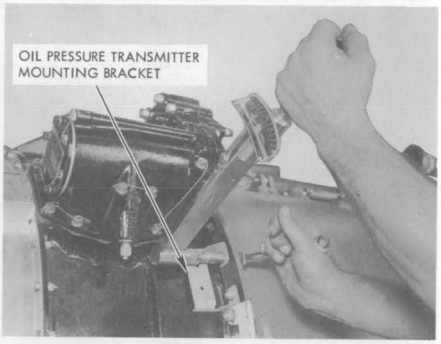
E. Position elbow and attach oil pressure sensing line. Tighten jam nut.



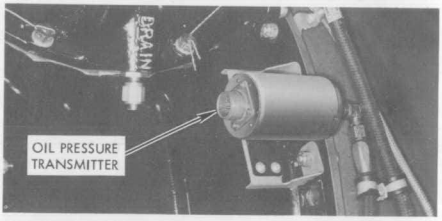
7 OIL PRESSURE TRANSMITTER INSTALLATION.-AIRPLANES 139531i THROUGH 143542k.

A. Remove bolts from compressor housing flange.

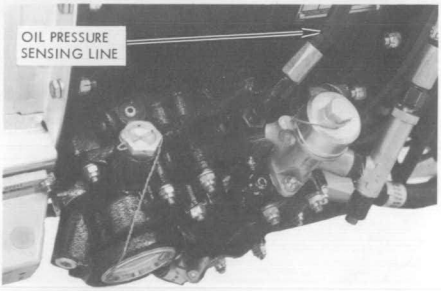
B. Install oil pressure transmitter mounting bracket using removed bolts. Torque bolts from 125 to 140 inch-pounds.



C. Install oil pressure transmitter on mounting bracket.



D. Connect oil pressure sensing line to connection on oil pump.

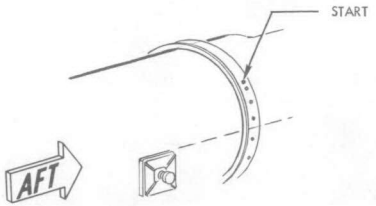


E. Connect clip on pressure sensing line to compressor housing flange.

FJ-4B-2-42-18A

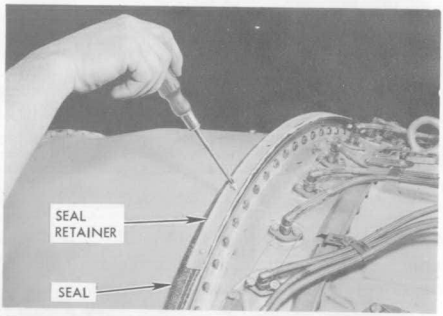
8 ENGINE FIREWALL BULB SEAL INSTALLATION.

A. Place engine firewall bulb seal on engine and retainers on top of seal. To position top retainer, count three holes up from imaginary line shown in detail below; place first screw in fourth hole.

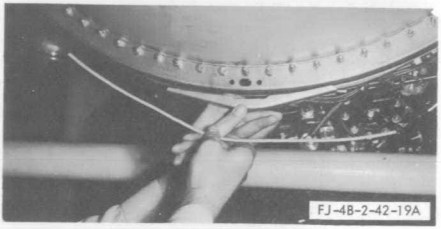


B. Punch hole through seal. Make sure that hole is punched through seal between two lines of white thread on seal.

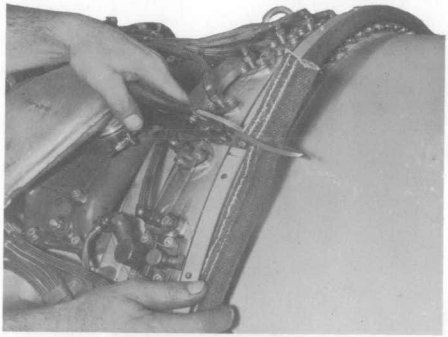
C. Insert screw through hole in retainer and fasten retainer to seal.



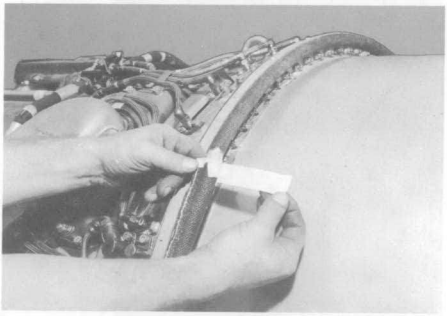
D. Install engine firewall bulb seal lower adapter on bottom of engine. Then install seal and retainer over adapter.



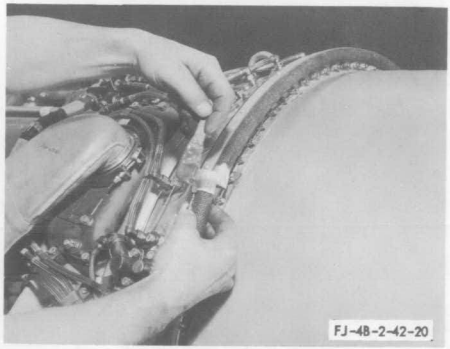
E. Trim seal off to proper length.



F. Place tape (item 127, materials list) over ends of seal and around end of seal.

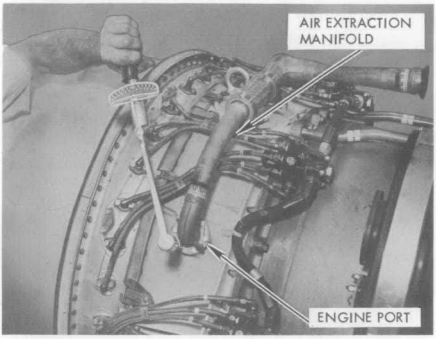


G. Apply cement (item 3, materials list) over tape on ends of seal and complete installation of seal and retainer.

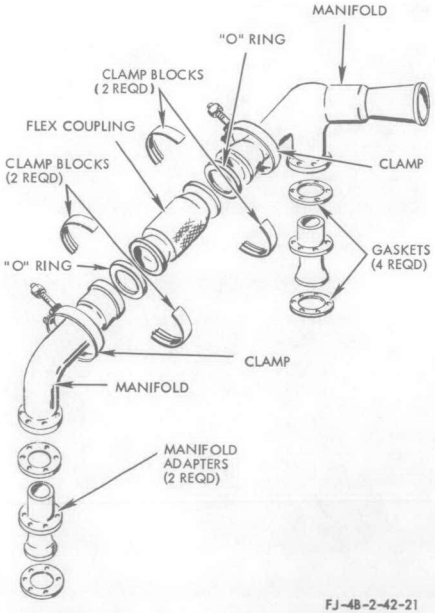


9 ENGINE COMPRESSOR AIR EXTRACTION MANIFOLD INSTALLATION.

A. Install manifolds with adapters and gaskets (two each). Torque bolts from 80 to 85 inch-pounds. Safety-wire bolts.



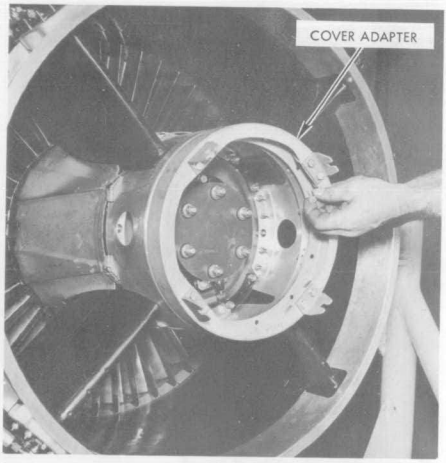
B. Install flex coupling with "O" rings. Position clamp blocks and clamps as shown.



FJ-4B-2-42-21

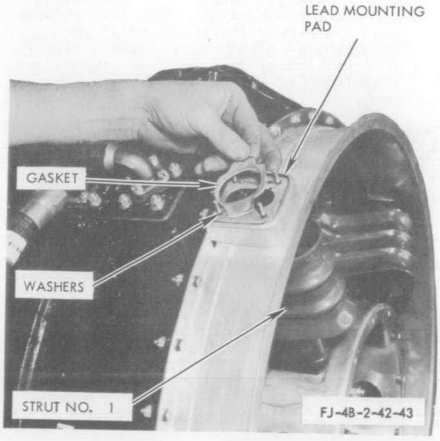
10 STARTER-GENERATOR INSTALLATION.

A. Install accessory cover adapter.

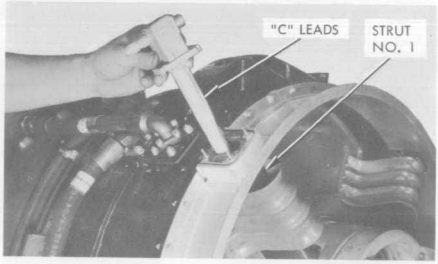


B. Remove covers from starter-generator lead mounting pads.

C. Add gasket and four washers to mounting pads on struts No. 1 and No. 4.



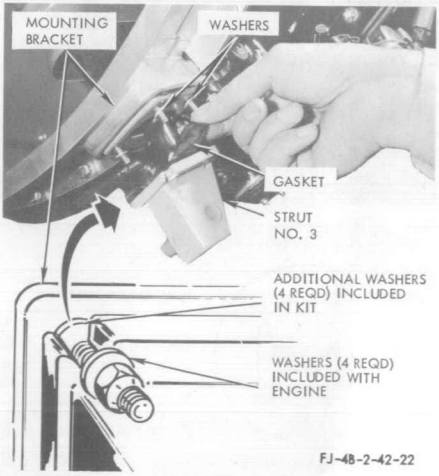
D. Insert starter-generator "C" leads through strut No. 1, and "B" leads through strut No. 4. Torque mounting nuts to 20 inch-pounds.



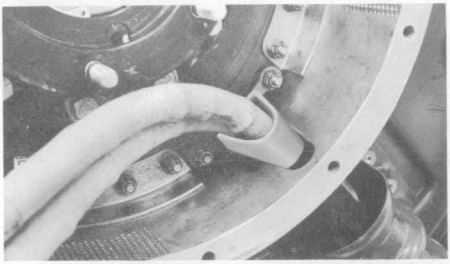
E. Remove engine air inlet guide. This step is necessary because the bracket through which the starter-generator "E" leads are installed must be removed and installed over the leads before the leads are installed on the engine.

F. Remove bracket from mounting pad and insert leads through gasket, four washers and mounting bracket.

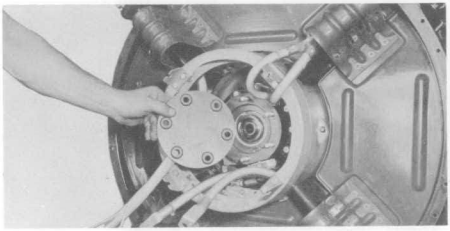
G. Insert starter-generator "E" leads in strut No. 3. Torque to 20 inch-pounds. Reinstall engine air inlet guide.



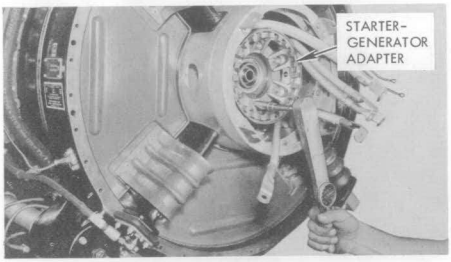
H. Install clip on starter-generator "E" leads.



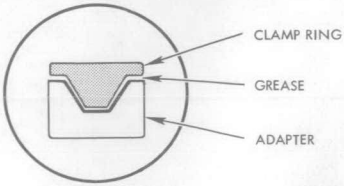
J. Remove starter-generator mounting pad cover.



K. Install starter-generator adapter with clamp bolt at approximately the 10 o'clock position when looking aft. Torque nuts from 275 to 300 inch-pounds.

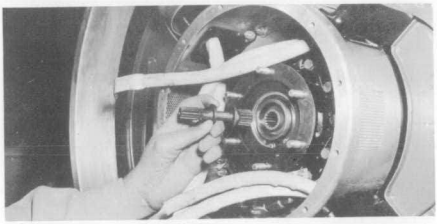


Note Apply grease (item 61, materials list) to clamp ring and groove in adapter.

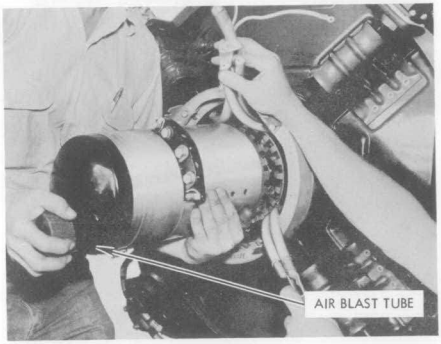


FJ-4B-2-42-23

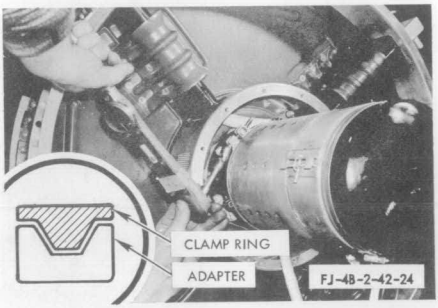
L. Insert starter-generator stub shaft.



M. Install starter-generator. For proper installation, the starter-generator air blast tube must be in the 6 o'clock position.

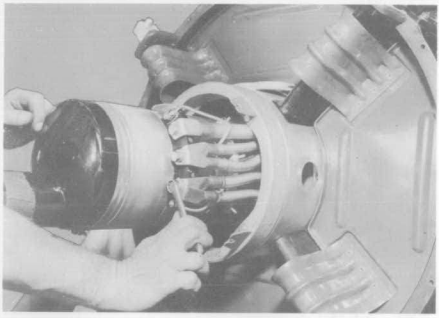


N. Secure starter-generator clamp ring. Grooves in teeth of starter-generator and adapter must align to allow clamp to seat properly. Make sure that clamp ring is seated securely in groove before tightening. The 7/16-inch hex head clamp bolt must be torqued to 120 inch-pounds, then loosened one-half turn and torqued again as required until bolt ceases to advance.

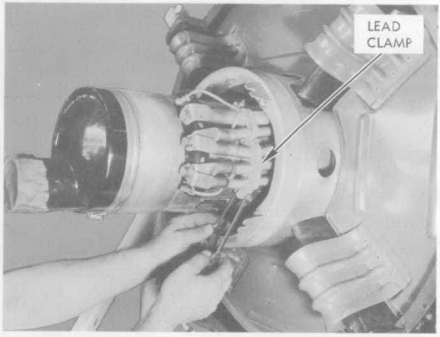


P. Connect starter-generator electrical leads to terminals. Torque bolts 150 (±3) inch-pounds.

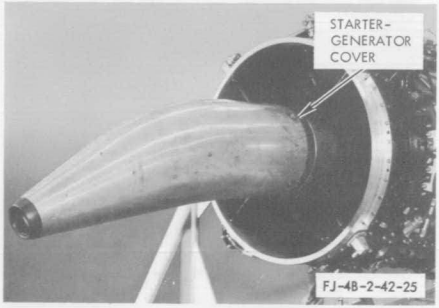
Q. Safety-wire terminal bolts.



R. Install starter-generator lead clamp.



S. Install starter-generator cover. Torque bolts from 35 to 50 inch-pounds.



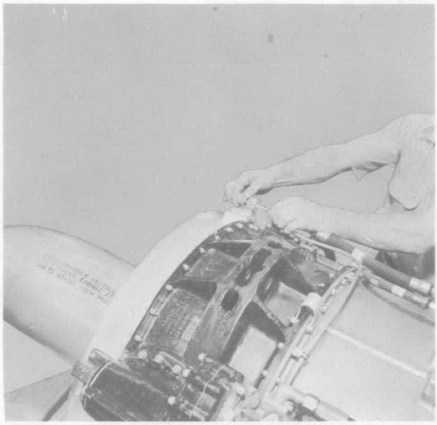
T. Install generator control lead on top of engine.

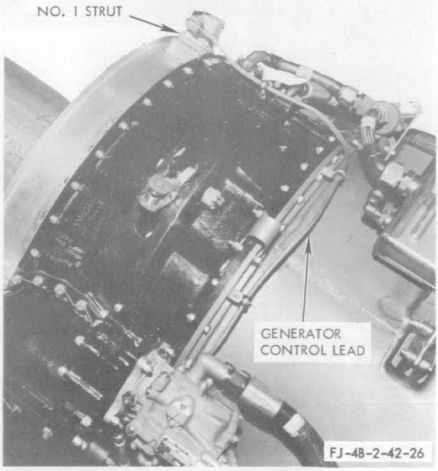
U. Clip lead to No. 1 strut. Torque bolt from 80 to 85 inch-pounds.

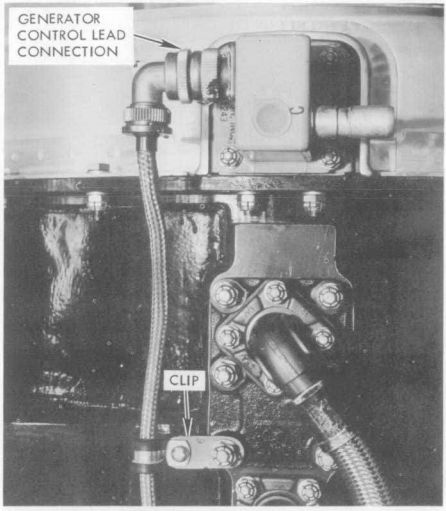
V. Clip lead to compressor flange in three places. (See detail.) Torque bolts from 125 to 140 inch-pounds.

W. Tighten generator control lead connection finger-tight.

X. Safety-wire generator control lead connection.

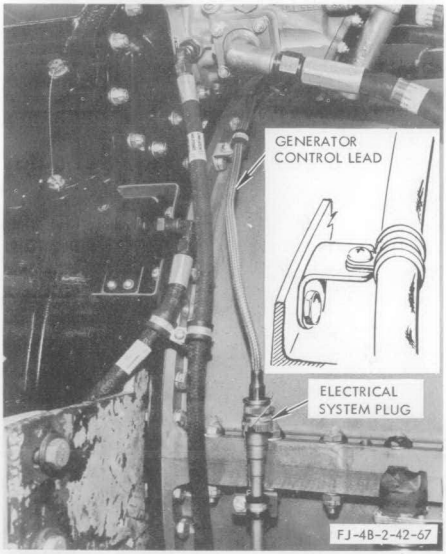






Y. Connect generator control lead to engine electrical system plug on left-hand side of engine.

Z. Safety-wire generator control lead to electrical system plug.

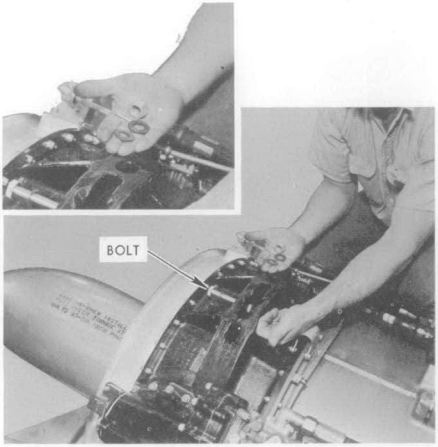


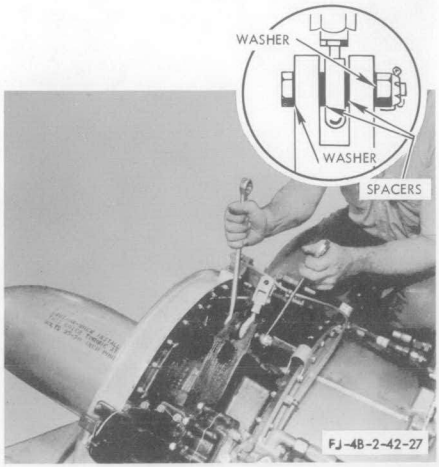
11 FORWARD STEADY SUPPORT INSTALLATION.

A. Install mounting bolt, washers and spacers.

B. Install forward steady support.

C. Insert cotter key in mounting bolt.

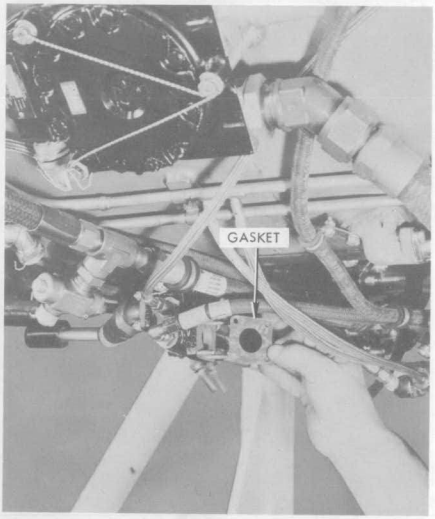




12 ENGINE OVERBOARD DRAIN LINE INSTALLATION.

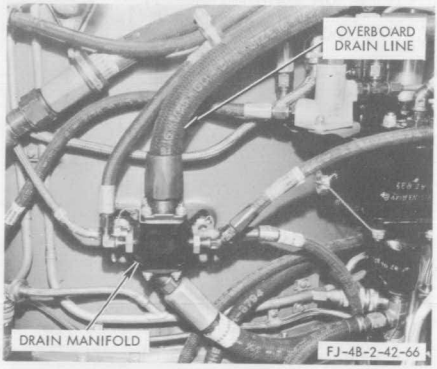
A. Remove cover from drain manifold located on bottom of engine.

B. Install gasket on drain manifold mounting pad.



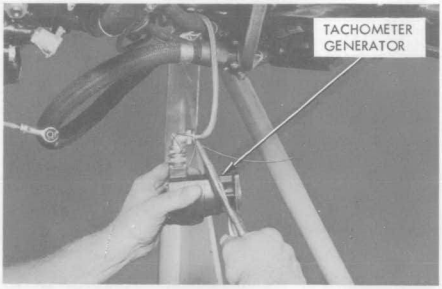
C. Remove packing plug from overboard drain line.

D. Install drain line fitting to drain manifold mounting pad.



13 TACHOMETER GENERATOR INSTALLATION

A. Remove cover from tachometer generator mount.

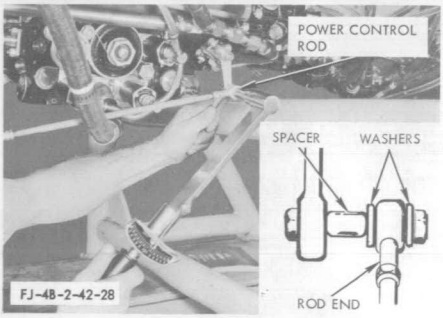


B. Connect electrical lead to tachometer generator and safety-wire. Connection of the electrical lead to the tachometer generator should be made prior to installing the generator.

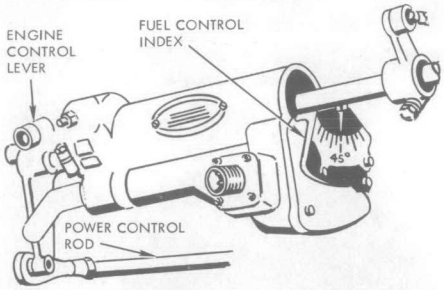
C. Install tachometer generator on mount.

14 ENGINE POWER CONTROL ROD INSTALLATION.

A. Install rod with spacer between rod end and engine control lever and washers on both sides of rod end.



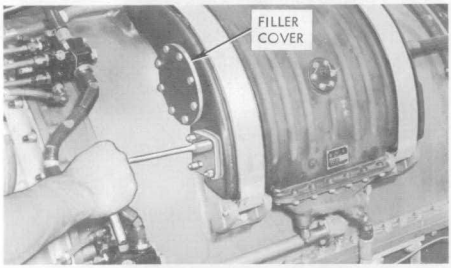
B. Check adjustment of control rod. With the engine control lever in a perpendicular position, the fuel control index should read 45 degrees.



15 OIL TANK FILLER ASSEMBLY INSTALLATION.

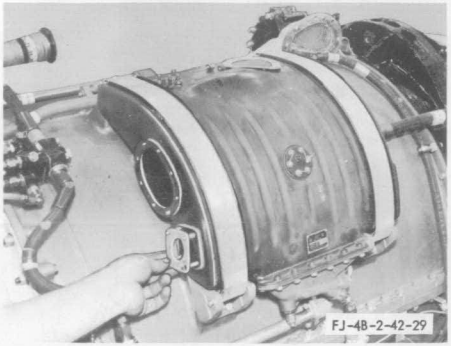
A. Remove oil tank filler cover and gasket.

B. Remove cover from door below filler door.

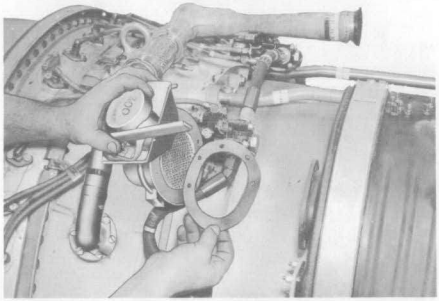


C. Install gasket on bottom door.

D. Install 194-47031 cover plate. Torque bolts from 40 to 50 inch-pounds.

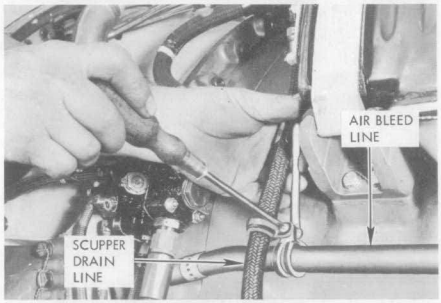


E. Install gasket and filler assembly on mount. Torque bolts from 40 to 50 inch-pounds and safety-wire.



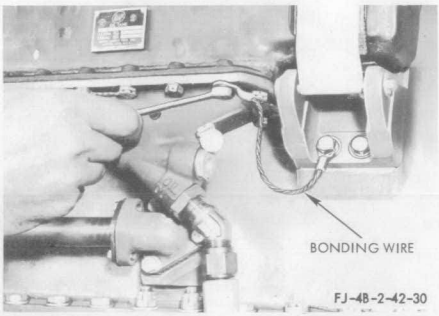
F. Connect scupper drain line to bottom of filler assembly.

G. Clamp line to compressor air bleed line.



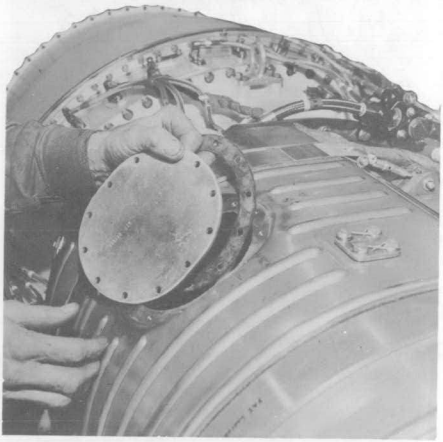
H. Remove bolt from tank flange and tank mount.

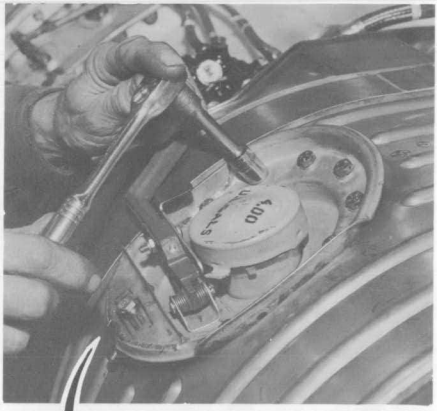
J. Install bonding wire and reinstall bolts. Safety-wire bolts on tank flange. Install washer first and then bonding wire.

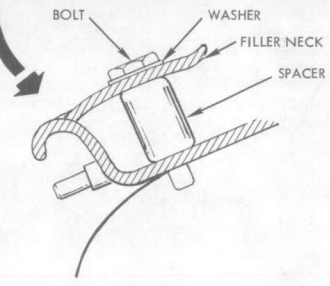


16 OIL TANK FILLER ASSEMBLY INSTALLATION - 4-GALLON OIL TANK.

A. Remove oil tank filler cover and gasket. Retain the bolts.

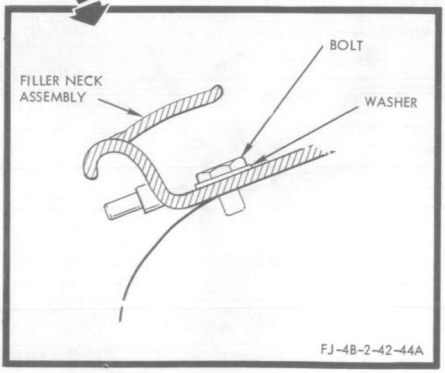






B. Install filler assembly with gasket. Use removed bolts and washers. Add one long bolt, washer and spacer as shown in detail below. Torque bolts from 40 to 50 inch-pounds and safety-wire.

Note On some installations the long bolt and spacer are not required. Install as shown below.

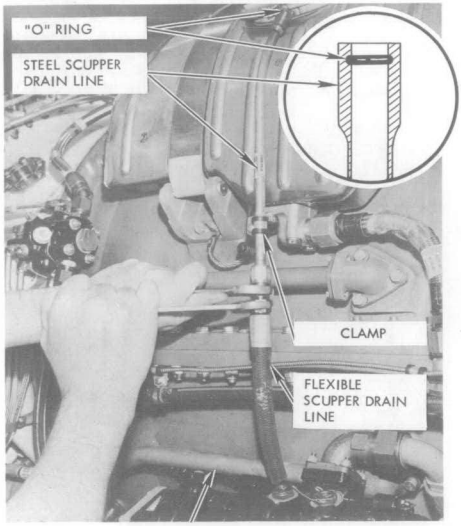


C. Install "O" ring on scupper drain.

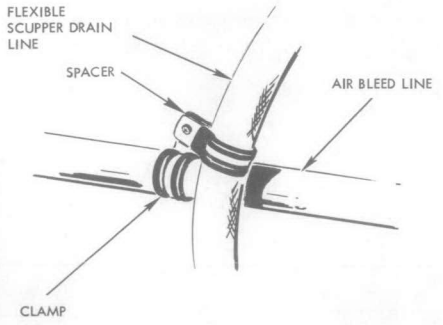
D. Install steel scupper drain line.

E. Clamp steel scupper drain line to oil tank sump.

F. Connect flexible scupper drain line to steel scupper drain line.



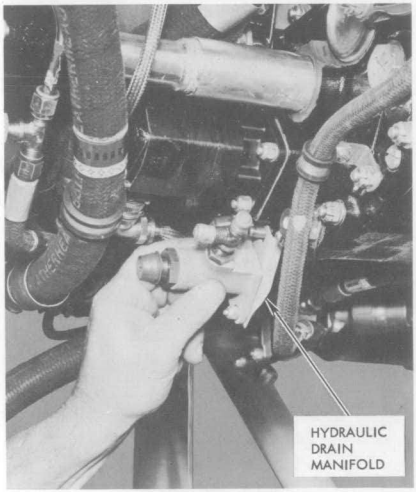
G. Clamp line to compressor air bleed line.



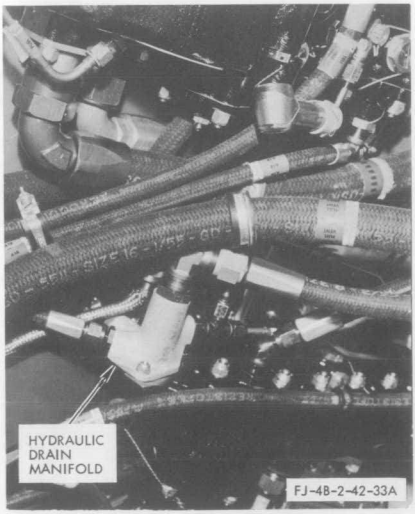
FJ-4B-2-42-32A

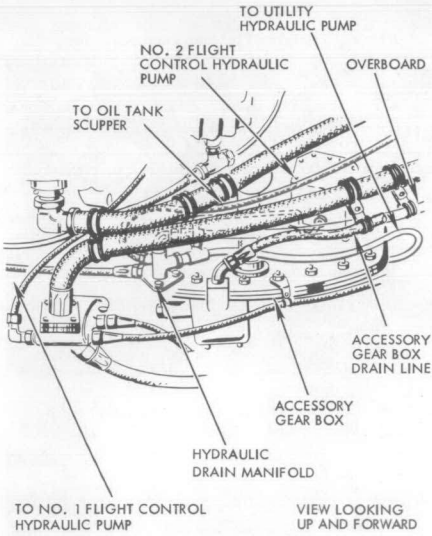
17 DRAINAGE PROVISIONS INSTALLATION.

A. Install hydraulic drain manifold on accessory gear box flange below tachometer generator.



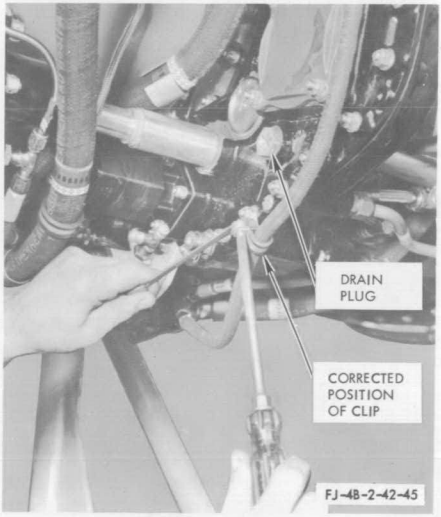
B. Connect drain lines to hydraulic drain manifold.



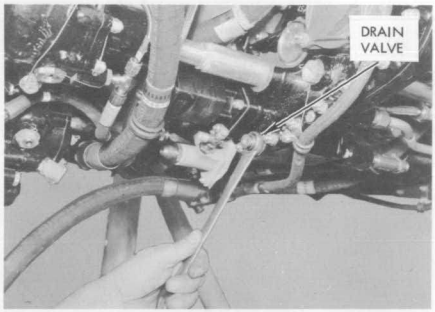


C. Relocate clip on fuel pump drain line to accessory gear box flange.

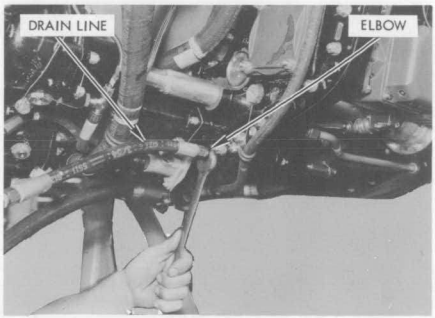
D. Safety-wire clip retaining bolt to drain plug on accessory gear box.



E. Remove accessory gear box drain valve and retain.



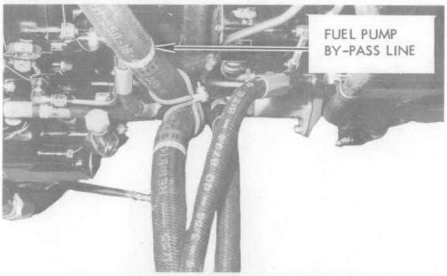
F. Install accessory gear box drain line with elbow.

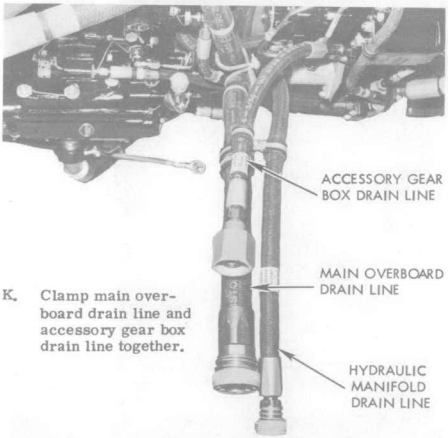


G. Remove plug from end of drain hose. Install drain valve guard and drain valve removed from accessory gear box.

H. Clamp main overboard drain line and hydraulic manifold drain line together.

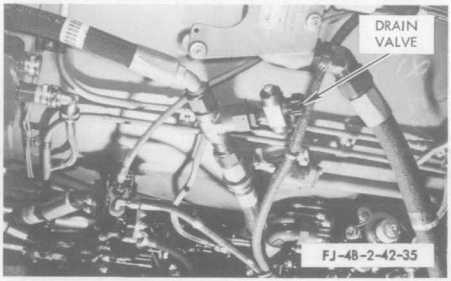
J. Clamp main overboard drain line and fuel pump by-pass line together.



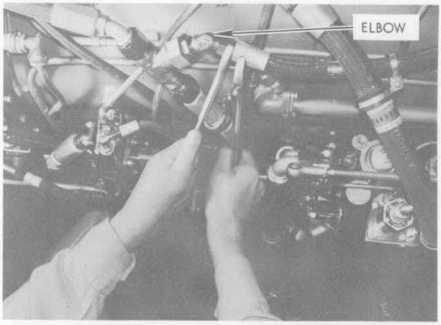


K. Clamp main overboard drain line and accessory gear box drain line together.

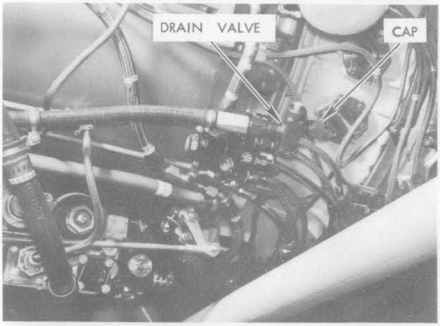
L. Remove drain valve from oil tank to oil pump line and retain.



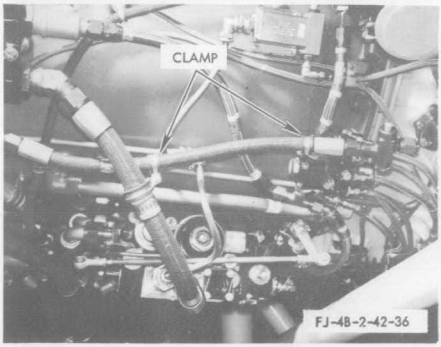
M. Install elbow in "T" fitting and connect oil pump drain line to elbow on oil tank to oil pump line.



N. Reinstall removed drain valve on end of oil pump drain line. Install cap on drain valve.



P. Clamp oil pump drain line to main fuel line and flow divider line.

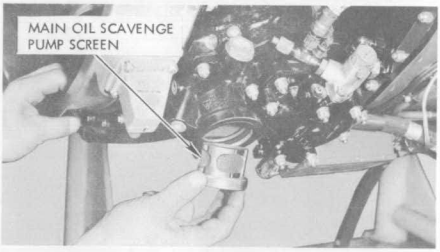


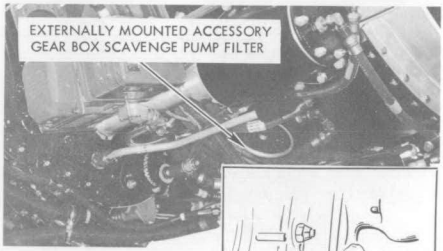
18 OIL PUMP FILTER SCREEN INSPECTION

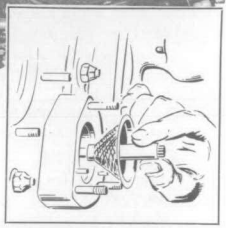
A. Remove main oil scavenge pump filter screen and externally mounted accessory gear box scavenge pump filter screen.

B. Inspect filter screens for foreign material.

C. Replace oil scavenge pump filter screens.







D. Remove and inspect accessory gear box scavenge oil pump inlet filter screen. Replace screen.

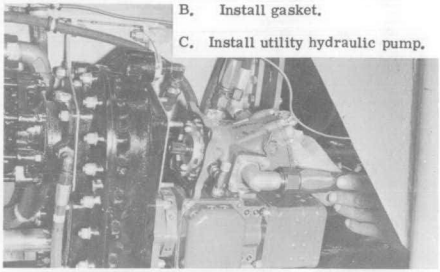
E. Remove main oil pump filter screen.

F. Inspect filter screen for foreign material.

G. Replace main oil pump filter screen.

19 UTILITY HYDRAULIC PUMP INSTALLATION.

A. Remove cover from utility hydraulic pump mounting pad.



B. Install gasket.

C. Install utility hydraulic pump.

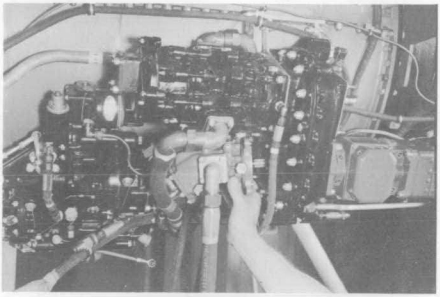
D. Torque mounting nuts from 125 to 140 inch-pounds.

20 NO. 2 FLIGHT CONTROL HYDRAULIC PUMP INSTALLATION.

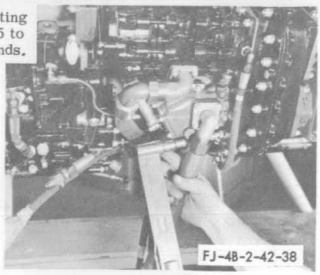
A. Remove cover from No. 2 flight control hydraulic pump mounting pad.

B. Install gasket.

C. Install No. 2 flight control hydraulic pump.

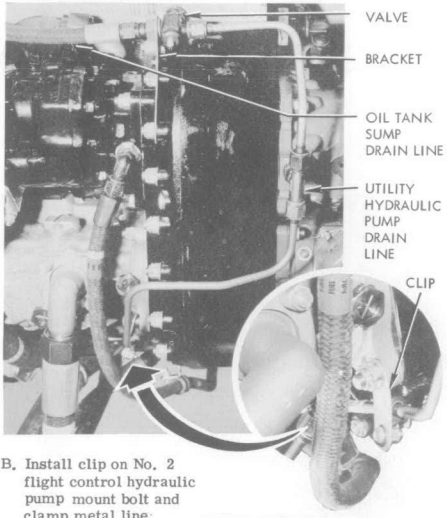


D. Torque mounting nuts from 125 to 140 inch-pounds.



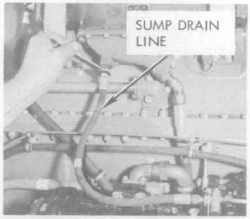
21 UTILITY HYDRAULIC PUMP DRAIN LINE AND OIL TANK SUMP DRAIN LINE INSTALLATION.

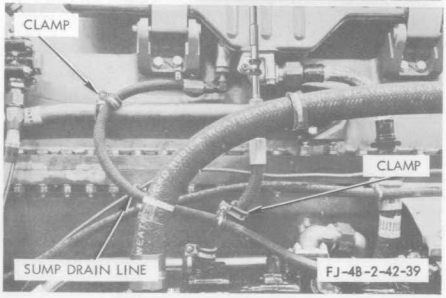
A. Install metal drain line on utility hydraulic pump and bracket on top of accessory gear box. Install valve on bracket.



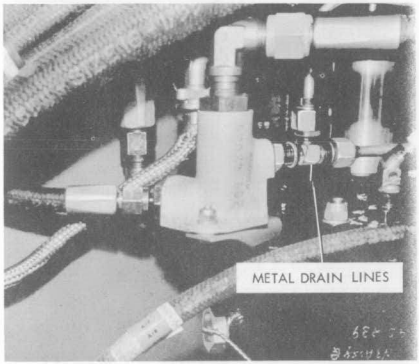
B. Install clip on No. 2 flight control hydraulic pump mount bolt and clamp metal line.

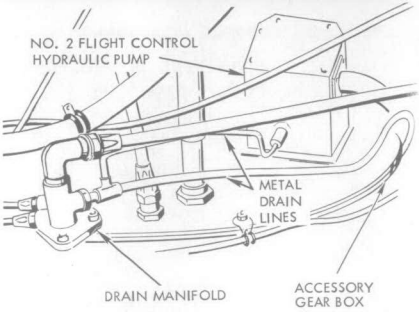
C. Install oil tank sump drain line from oil tank sump to drain line bracket.



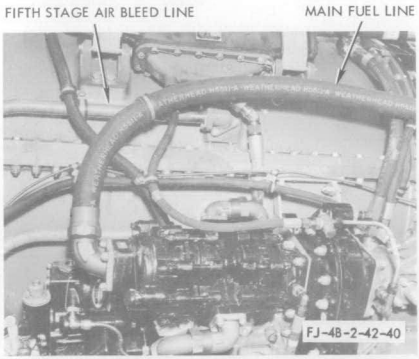


D. Connect metal drain lines to fitting on manifold drain on bottom of engine.



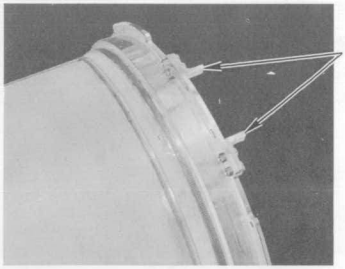


E. Install main fuel inlet line and clamp to fifth stage air bleed line.

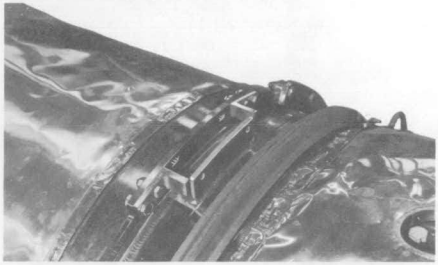


22 EXHAUST TAIL-PIPE INSTALLATION.

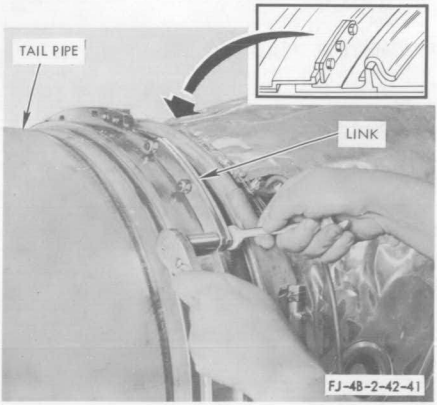
A. Install exhaust tail-pipe radial supports (right- and left-hand).



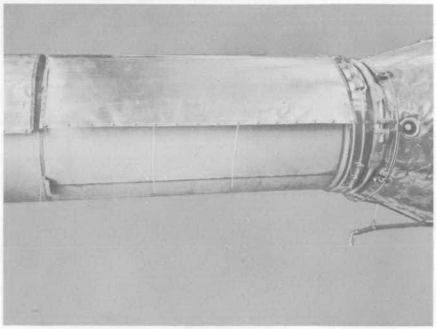
B. Install exhaust tail pipe. Tail-pipe radial supports must be located at top of tail pipe before tail pipe is in correct position for installation.



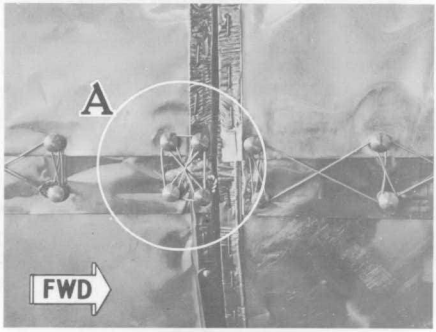
C. Install tail-pipe support links. Lubricate bolt threads with grease (item 8, materials list).

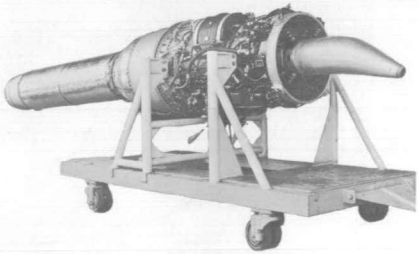


D. Install tail-pipe blankets.



E. Keep the end with the four fasteners (Detail A) forward as shown.





FJ-48-2-42-42

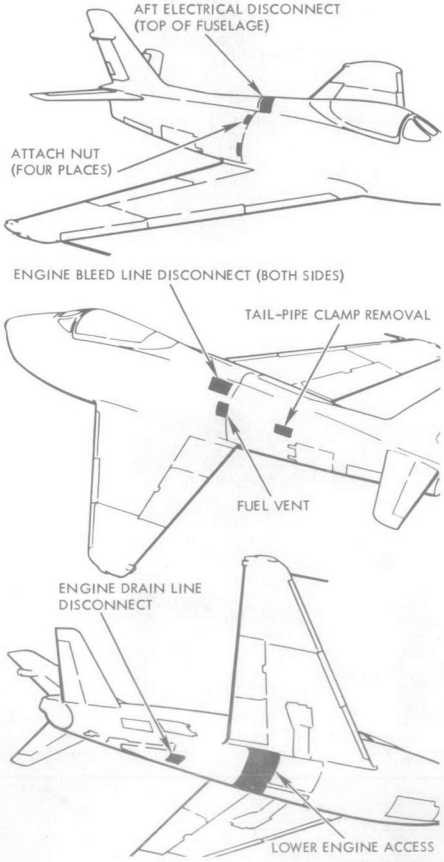
5-6. REMOVING AND INSTALLING FUSELAGE AFT SECTION.

1 Defuel airplane.

Note When using the air logistics dolly (Part No. 4000A) and the aft fuselage adapters (E6076), step one may be omitted.

2 Fully deflate the nose gear strut and fully inflate the main landing gear struts.

3 Open the following access doors:

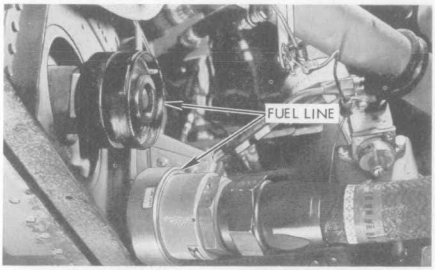


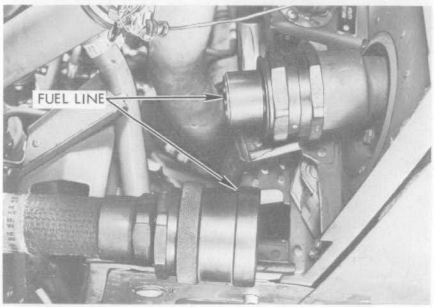
FJ-48-2-31-1

4 Dump the flight control hydraulic accumulators.

5 Through the engine access door, disconnect the following:

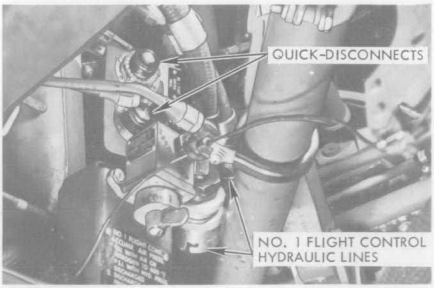
Two fuel lines to aft cell.





No. 1 Flight Control Hydraulic Pressure Line

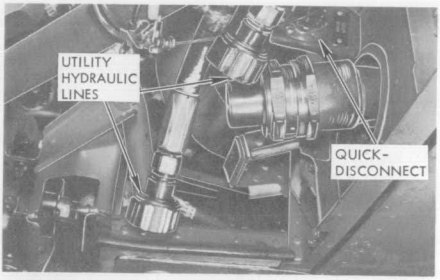
No. 1 Flight Control Hydraulic Return Line



FJ-48-2-31-2

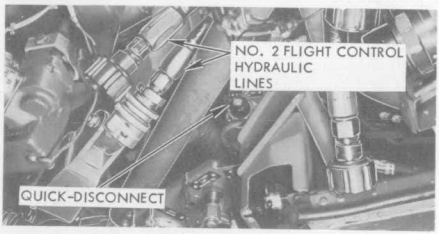
Utility Hydraulic Pressure Line

Utility Hydraulic Return Line



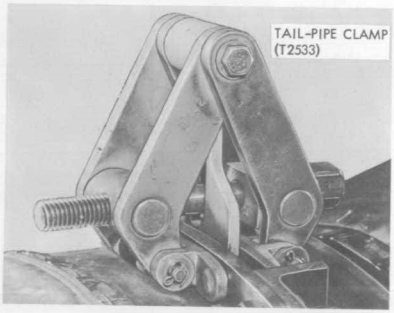
No. 2 Flight Control Hydraulic Pressure Line

No. 2 Flight Control Hydraulic Return Line



6 Lower the flaps.

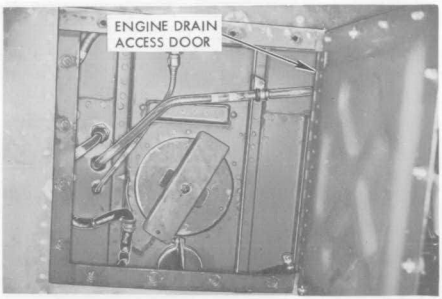
7 Install engine tail-pipe ball joint support clamp (T2533).



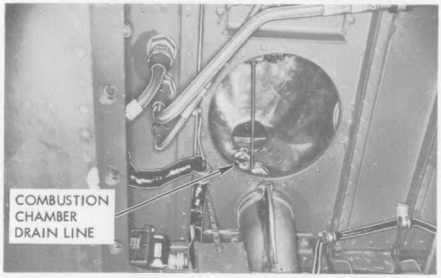
FJ-48-2-31-3

Caution Attempting to remove the aft fuselage section with the engine tail-pipe unsupported will result in damage to the tail pipe.

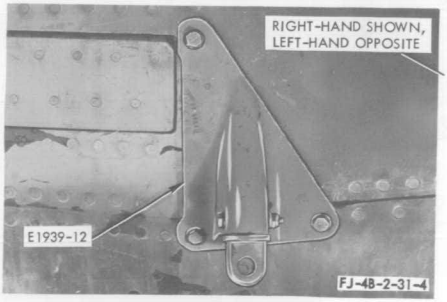
8 Through the engine drain access door, disconnect the combustion chamber drain line.



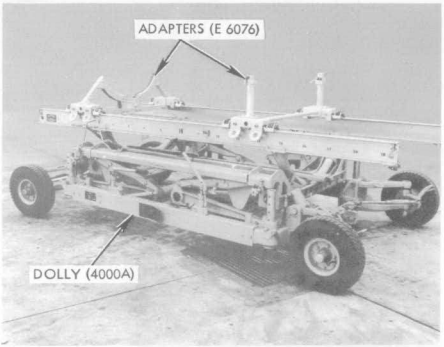
Note Stow drain line on clip provided so that line will not become fouled during aft section removal.



9 Install E1939-11 and -12 fittings on aft fuselage.



10 Move dolly (4000A) with adapters (E6076) into position and attach to aft section.



11 Through engine bleed line access door (LH side), disconnect the following:

A. Two horizontal stabilizer control cables

B. Rudder control cable

12 Through fuel vent access door, disconnect the following:

A. Speed brake dump cables

B. Fuel vent

13 At top of fuselage, disconnect the following:

A. Two fuel quantity indicating system coaxial cables

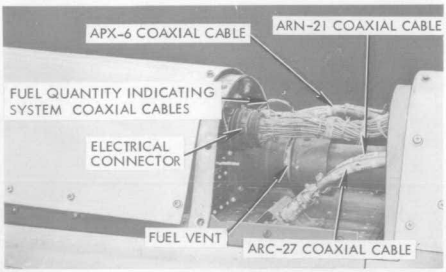
B. One electrical connectors

C. ARN-21 coaxial cable

D. ARC-27 coaxial cable

E. APX-6 coaxial cable

F. Fuel vent



FJ-4B-2-31-5

14 Through the engine bleed line access door (RH side), disconnect the following:

A. Two horizontal stabilizer control cables

B. Rudder control cable

C. Arresting gear control cable

Caution Prior to disconnecting control cable, secure arresting hook in the up position using E2747 arresting gear support.

15 Using forward to rear fuselage attach fitting torque wrench adapter (T258), disconnect attach nuts (four places).

16 With all control cables and lines supported so that they will not foul on airplane structure, carefully remove the fuselage aft section from the airplane.

INSTALLING

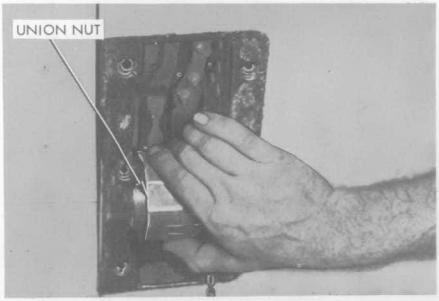
Note Secure all hydraulic lines, control cables, electrical wiring and other loose equipment so that they will not become fouled on fuselage structure. Check for proper installation of engine ball joint support clamp (T2533).

1 Lubricate fuel vent "O" rings with anti-seize compound (item , materials list).

2 With wing flaps in down position, carefully move fuselage aft section forward over engine tail pipe until indexing pins are fully engaged in indexing holes.

Note While moving aft section into position, ensure that arresting gear cable and speed brake dump cables are correctly routed through holes in forward section bulkhead.

3 With aft section butted firmly against forward section, fasten union nuts.

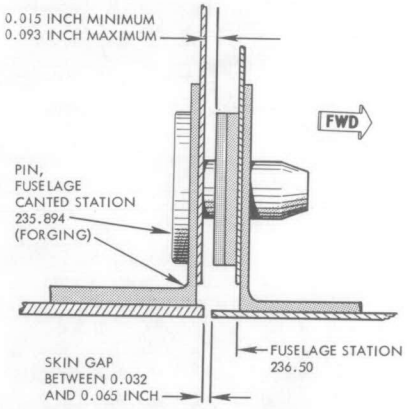


FJ-4B-2-31-6

Note To facilitate subsequent removal, lubricate field break stud threads with anti-seize compound (item 9 , materials list) before starting union nuts.

4 Torque all union nuts to 8400 (+500/-000) inch-pounds. Safety with AN995N51 safety wire.

Note With adapter (T2588) on torque wrench, correct dial reading must be computed using the formula provided in figure



Note Clearance between the aft face of the forward indexing fitting and the forward face of the aft section bulkhead at fuselage station 236.25 should be 0.015 inch minimum to 0.093 inch maximum. Skin gap at fuselage station 236.25 should be between 0.032 and 0.065 inch.

5 Disconnect and remove fuselage dolly and adapter. Remove adapter attach fittings and replace screws.

6 At top of fuselage, connect following:

A. ARN-21 coaxial cable

B. ARC-27 coaxial cable

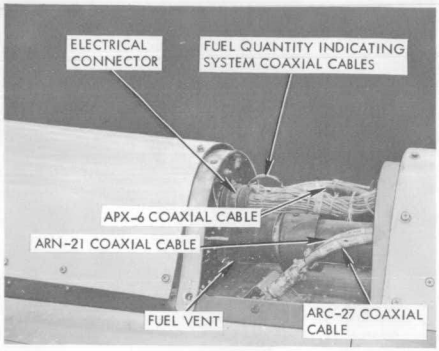
C. Fuel quantity indicating system coaxial cables

D. APX-6 coaxial cable

E. One electrical connector

F. Fuel vent

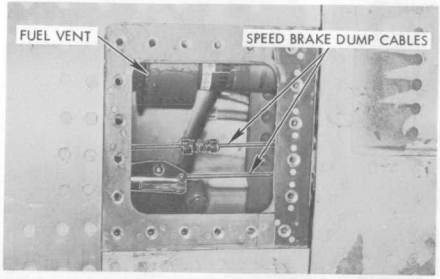
FJ-4B-2-31-7



7 Through fuel vent access opening, connect the following:

A. Two speed brake dump cables.

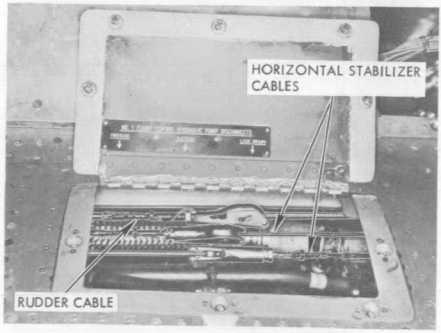
B. Fuel vent.



8 Through engine bleed line access door (LH side), connect the following:

A. Two horizontal stabilizer control cables.

B. Rudder cables.



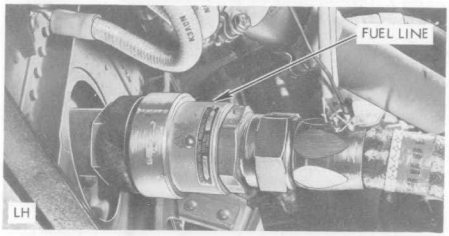
FJ-4B-2-31-8

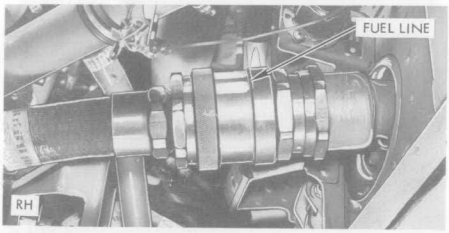
9 Through engine bleed line access door (RH side), connect the following:

A. Two horizontal stabilizer control cables.
B. Rudder control cable.
C. Arresting gear control cable.

10 Through engine access door, connect the following:

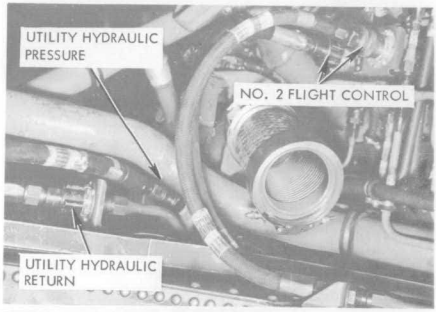
A. Two fuel lines



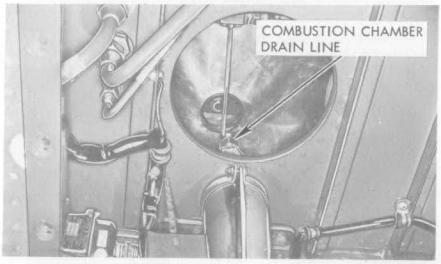


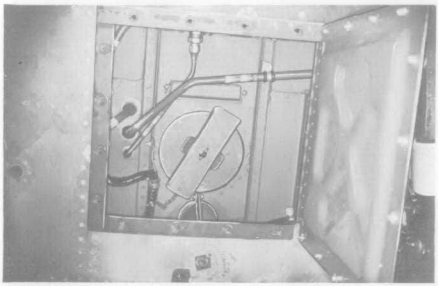
B. Two No. 1 flight control hydraulic lines

C. Two No. 2 flight control hydraulic lines
D. Two utility system hydraulic lines



11 Through engine drain access door, connect combustion chamber drain line.





12 Remove engine tail-pipe clamp.

13 Check complete installation for security. Check fuel and hydraulic lines for leaks. Perform functional checks on rudder control system, horizontal stabilizer control system, speed brake dump system and arresting gear control system. Check engine tail pipe clearance.

14 Secure all access doors.

FJ-48-2-31-10

5-7. REMOVING AND INSTALLING ENGINE.

REMOVING

1 Remove aft fuselage section. (Refer to paragraph 5-6.)

2 Open left- and right-hand engine access doors, engine access door on bottom of fuselage and the left- and right-hand wheel well access doors.

Note Accomplish steps 3 through 7 through the right-hand engine access door.

3 Disconnect utility hydraulic pump suction line.

4 Disconnect utility hydraulic pump pressure line.

5 Disconnect utility hydraulic pump case drain line.

6 Disconnect starter-generator ground lead.

7 Disconnect main fuel line at fuel shutoff valve.

Note Accomplish steps 8 through 14 through fuselage break.

8 Disconnect hydraulic manifold drain line.

9 Disconnect No. 2 flight control hydraulic pump suction line.

10 Disconnect No. 2 flight control hydraulic pump case drain line.

11 Disconnect No. 2 flight control hydraulic pump pressure line.

12 Disconnect accessories drain line.

13 Disconnect oil vapor outlet on left- and right-hand sides.

14 Disconnect engine power control rod assembly at the connection on the adjusting plate. Remove the power control rod with the engine.

Note

- Secure all the disconnected and hanging lines, hoses, ducting and electrical wiring with cord to prevent damage or interference during engine removal.
- Accomplish steps 15 through 20 through the left-hand engine access door.

15 Remove safety wire from main electrical lead connection and disconnect lead.

16 Remove safety wire and disconnect emergency ignition switch lead.

17 Remove safety wire and disconnect thermocouple lead.

Note Access to the three electrical disconnects may also be gained through the left-hand disconnect door located just aft and slightly above the left-hand engine access door.

18 Disconnect starter-generator lead.

19 Disconnect oil pressure switch lead.

20 Disconnect the cockpit air conditioning bleed line.

21 Through the left-hand wheel well access door, disconnect the starter-generator lead on the bottom of the engine.

22 Two methods can be used for removing the engine from the airplane. If a hoist is used, fasten rear end of engine hoist sling to the lifting ring on top of the engine just forward of the center main bearing section. Raise the hoist just enough to tighten sling. If an engine dolly is used, engage pins on dolly into fittings on engine main trunnion mount. (Refer to paragraph 1-17.)

23 Through left- or right-hand engine access door, remove pin from forward steady support. The pin is to remain in the airplane. Make sure that the retaining chain fastened to the pin is secured to the airplane.

24 Place a bolt or similar object in the hole in the end of the track on which the forward steady support rides. This prevents the engine from rolling aft and off the track.

Note Accomplish steps 25 through 27 through the left-hand disconnect door located aft and slightly above the left-hand engine access door.

25 Disconnect No. 1 flight control hydraulic pump pressure line.

26 Disconnect No. 1 flight control hydraulic pump case drain line.

27 Disconnect No. 1 flight control hydraulic pump suction line.

28 Loosen and open engine main trunnion mounts.

29 Make sure that all engine-to-airplane disconnects have been accomplished and are clear; then, carefully roll the front section of the fuselage away from the engine or the engine away from the fuselage.

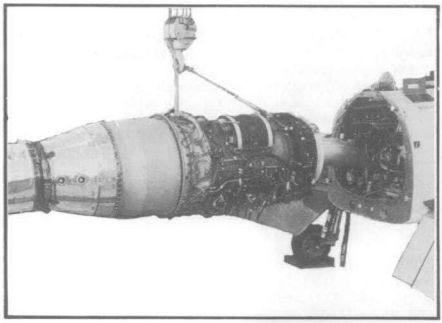
30 Remove bolt from end of track and remove engine from fuselage. If engine is to be sent to overhaul, remove all engine-to-airplane adapting parts for reinstallation. Close all lines and openings to prevent entry of dirt or foreign materials.

INSTALLING

1 Before installing, depreserve engine in accordance with General Gas Turbine Bulletin, No. 15 and Handbook of Service Instructions (AN 02B-35AAC-2).

Note The engine may be installed using an engine hoist or an engine dolly. In the following illustration, an engine hoist is used. To install the engine on the dolly prior to installing the engine in the airplane, refer to paragraph 1-17.

2 Build up engine. (Refer to paragraph 5-5.) Make sure all three hydraulic pumps have been filled with hydraulic fluid (item 95, materials list) through case drain ports. Stow and lash all lines, hoses and wiring to prevent interference during engine installation; then, attach engine sling. Lift and align engine with fuselage front section.



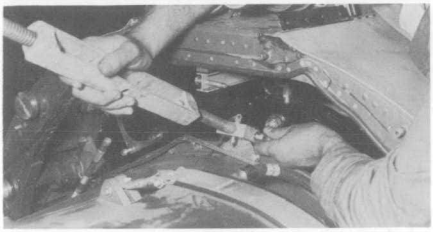
3 Roll fuselage front section back, or move engine forward, engaging forward steady support rollers in fuselage guide track.

4 With forward steady support engaged on the track, insert a bolt or similar object in the hole in the end of the track. This is to prevent the engine from going backwards off the track.

Note After forward steady support is engaged on track, avoid excessive shaking or sideward movement of engine to prevent damage to the track.

FJ-48-2-42-50A

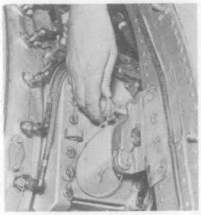
5 Remove the forward end of the engine hoist sling from the forward lifting eye on the engine.



Note Special care must be observed during installation to make sure that all lines are in the correct position. Make sure that the utility hydraulic pump suction line is pointed forward. The power control rod on the bottom of the engine should be removed and the forward end installed in the bottom of the fuselage. As the engine is moved forward, guide the rod between the engine and the main fuel line. (See step 20.)

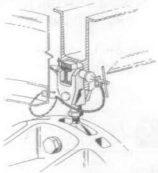
6 Slowly move the engine forward into the fuselage. When starter-generator terminals are opposite the left- and right-hand engine access doors, connect the starter-generator leads at No. 1, 3 and 4 struts. The starter-generator terminal on the No. 3 strut is accessible through the left-hand wheel well access door.

7 Move engine forward into main trunnion mounts and secure mounts.



Note Prior to inserting ball into socket of trunnion mount, lubricate both the ball and the socket sparingly with grease (item 61, materials list).

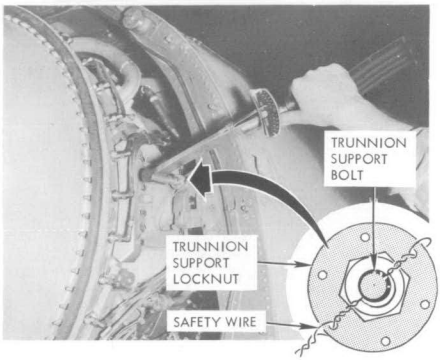
8 Through left- or right-hand engine access door, insert lockpin into forward steady support. To aid lockpin installation, it may be necessary to have a man jiggle the aft end of the tail pipe up and down.



Warning Make sure that the lockpin is fastened securely to the fuselage by the chain attached to it. If the lockpin is not fastened to the fuselage, it may become loose from the steady support and be drawn into the air intake duct of the engine.

FJ-48-2-42-51

9 Align engine with fuselage. See figure 5-7.) Torque engine trunnion support locking nuts between 160 and 190 inch-pounds and safety. (See detail)

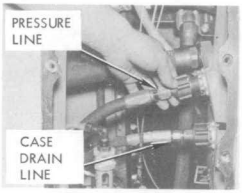


10 Remove aft end of engine hoist sling from aft lifting eye on engine. Accomplish steps 10 through 13 through the right-hand access door.

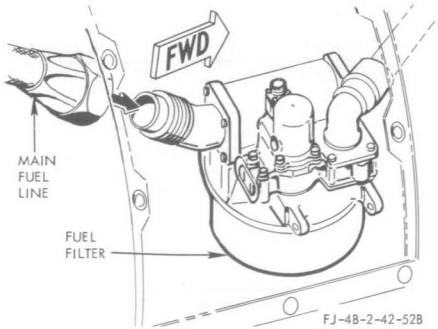
11 Connect utility hydraulic pump suction line.

12 Connect utility hydraulic pump pressure line.

13 Connect utility hydraulic pump case drain line.



14 Connect engine main fuel line.



FJ-4B-2-42-52B

Note Accomplish steps 14 through 20 through the fuselage break.

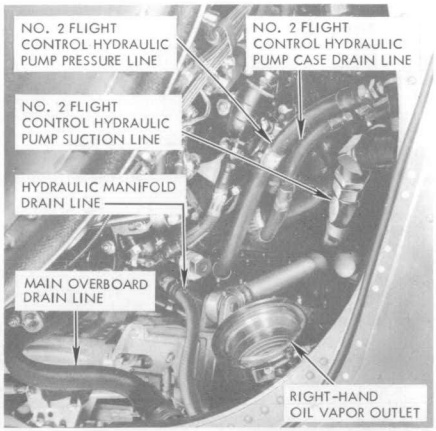
15 Connect No. 2 flight control hydraulic pump pressure line.

16 Connect No. 2 flight control hydraulic pump suction line.

17 Connect No. 2 flight control hydraulic pump case drain line.

18 Connect engine main drain line.

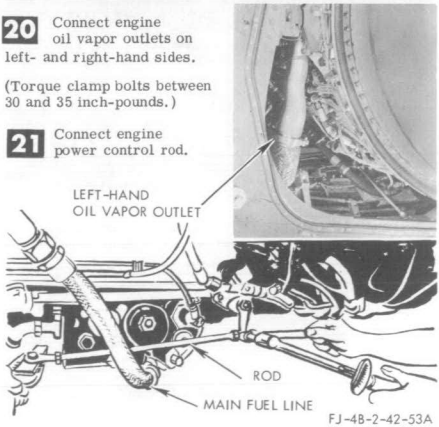
19 Connect hydraulic manifold drain line.



20 Connect engine oil vapor outlets on left- and right-hand sides.

(Torque clamp bolts between 30 and 35 inch-pounds.)

21 Connect engine power control rod.



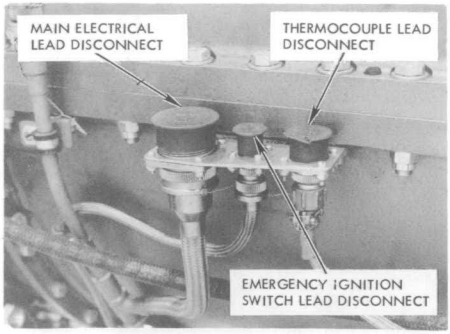
FJ-4B-2-42-53A

Note Accomplish steps 22 through 25 through the left-hand engine access door.

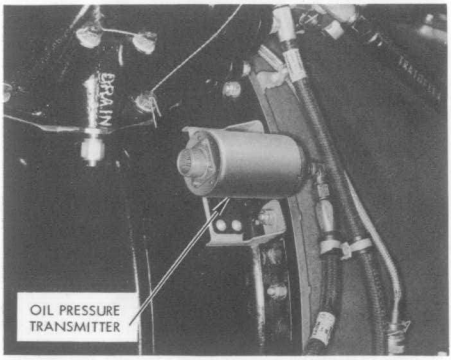
22 Connect and safety engine main electrical lead.

23 Connect and safety emergency ignition switch lead.

24 Connect and safety thermocouple lead.



25 Connect oil pressure transmitter lead to oil pressure transmitter.



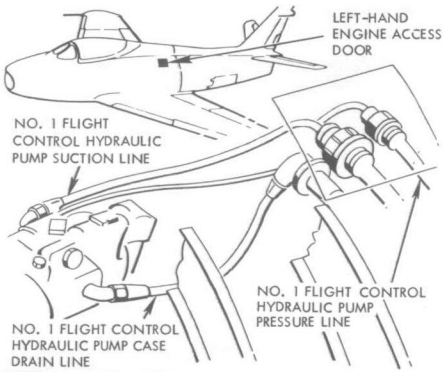
Note Accomplish steps 26 through 28 through the left-hand disconnect door located aft and slightly above the left-hand engine access door.

26 Connect No. 1 flight control hydraulic pump suction line.

27 Connect No. 1 flight control hydraulic pump case drain line.

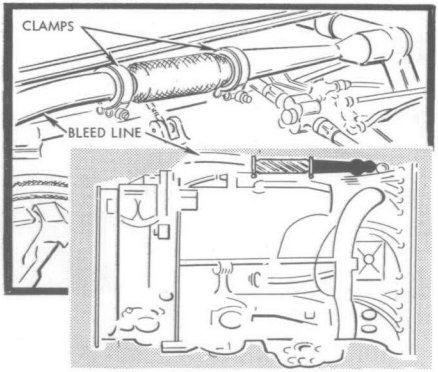
28 Connect No. 1 flight control hydraulic pump pressure line.

FJ-4B-2-42-54

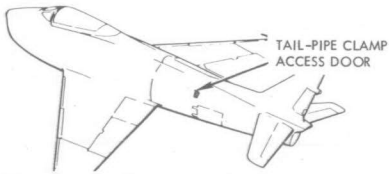


29 Through the left-hand engine access door on the top side of the fuselage, connect the cockpit air-conditioning bleed line.

Warning Clamps must be positioned as shown below to prevent interference with control cable disconnects.

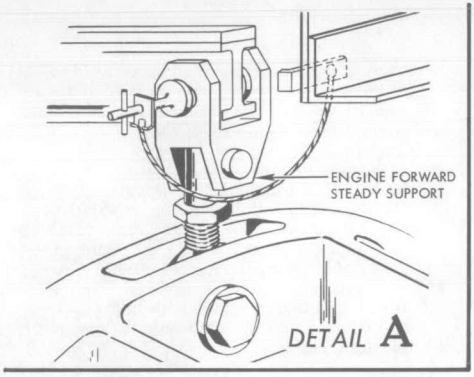


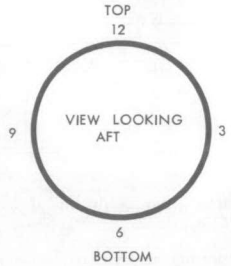
30 Remove the tail-pipe clamp through the tail-pipe clamp access door on the left-hand side of the aft fuselage section

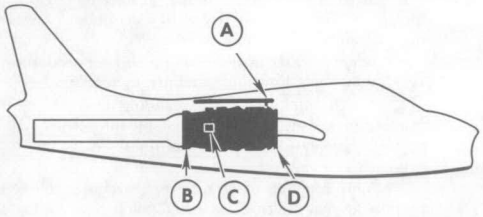


31 Perform preoperational check and initial engine run-up. (Refer to paragraphs 5-12 and 5-16.)

FJ-4B-2-42-55B







POSITION	DIM. A
12	3/16 MIN
3	1/8 MIN
6	3/16 MIN
9	9/32 MIN

POSITION	DIM. B
12	15/16 MIN
3	7/8 MIN
6	15/16 MIN
9	1-1/32 MIN

Note Either set of dimensions in detail D may be used for determining proper clearances. Engine must be aligned when cold, as clearances shown provide for expansion after engine becomes hot. To obtain the required clearances and alignment, either adjust forward steady support or remove engine and relocate eccentric trunnion ball on right side of engine or do both.

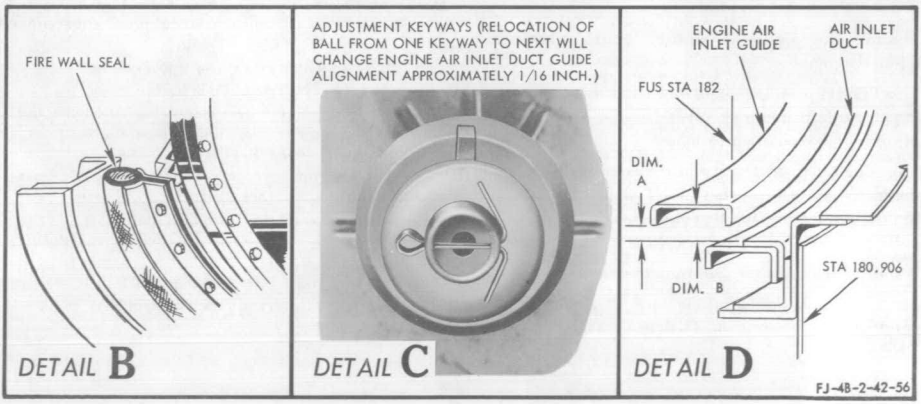


Figure No. 5-7. Alignment of Engine to Fuselage

5-8. ALIGNING ENGINE TO FUSELAGE.

5-9. Engine and fuselage alignment is accomplished by adjustment of the right trunnion mount and the top forward steady support. The ball of the right trunnion mount is eccentric and keyed to the trunnion shaft. Five keyways on the trunnion provide adjustment of the eccentric ball to obtain proper lateral alignment of the engine to the fuselage. The engine and fuselage alignment procedure (figure 5-7) is normally accomplished during engine installation.

5-10. PREOILING ENGINE.

5-11. The engine must be preoiled when any of the following conditions exist:

a. Immediately prior to the initial start of a new engine in an airplane.

b. Before starting a newly overhauled engine in an airplane or in a test stand.

c. At the initial start of an engine that has been treated for storage.

d. Immediately prior to depreservation of fuel system (at least 8 hours prior to starting engine).

e. Whenever an oil pressure line has been disconnected.

f. If engine has not been preoiled or flight operated within the last 7 days.

WARNING

Engine ground running should not be used as a substitute for preoiling.

The following precautions must be observed when preoiling the engine:

a. Prior to preoiling, drain center and rear main bearing external oil lines to prevent excessive accumulation of oil in the combustion chamber.

b. Check for any leakage in the external oil lines to the center and rear main bearings. Even a slight leak can considerably reduce oil flow and completely starve a bearing.

Preoil the engine in the following manner:

a. Check oil level in oil tank and service tank if oil is not at top of filler neck. (Refer to paragraph 1-36.)

CAUTION

The oil level in the engine oil tank should be at the top of the filler neck; however, if the engine is idle several hours after being serviced with oil, there is a possibility the oil level will drop due to leakage past the engine oil pump check valve into the accessory gear box. If the oil level is low, motor the engine until approximately 12% rpm is attained. If the level has not risen to the top of the filler neck, wait 3 minutes and again motor the engine until approximately 12% rpm is reached. After the second motoring, add oil, if necessary, to bring the oil level to the top of the filler neck. Refer to paragraph 5-14 for information on how to motor the engine.

b. Bleed any air present in the oil inlet line by opening the oil pump drain valve until a continuous flow of oil is obtained. Close drain valve.

c. Remove center main bearing preoil connection cap at oil pump and allow oil to drain from opening.

d. Attach inlet line from preoiling tank to preoil connection and pump 8 ounces of oil into center main bearing. Reinstall and safety-wire the preoil connection cap.

e. Pump 8 ounces of oil into rear bearing preoil connection at rear bearing metering pump. Reinstall and safety-wire the preoil connection cap.

f. Open spring-loaded drain valve on line from lower aft side of accessory gear box.

g. Pump oil at between 20 and 25 psi into preoil connection located just aft of oil pressure indicator connection on oil pump body.

h. Stop preoiling when oil starts to flow out of open spring-loaded drain valve on lower aft side of accessory gear box. Release drain valve at bottom of accessory gear box and reinstall and safety-wire preoil connection cap.

5-12. PREOPERATIONAL CHECK OF NEWLY INSTALLED ENGINE.

5-13. After installing a new or overhauled engine and before attempting operation, the engine must be checked as follows to determine that the installation is operative:

a. Check alignment of engine air inlet guide with engine air inlet duct. (See figure 5-7.)

b. Service fuel, oil and hydraulic systems. (Refer to paragraphs 1-34, 1-36, 1-41 and 1-42 for servicing systems.)

c. Preoil engine. (Refer to paragraph 5-10.)

d. Place all switches and power control lever in "OFF" positions.

1. Obtain AN3100-12S-2P connector .

2. Solder a jumper wire across the "A" and "B" pins of the connector.

3. Disconnect the lead from the magneto generator to the ignition system microswitch receptacle on the fuel control unit. The ignition system microswitch receptacle is located on the bottom, aft, left-hand side of the fuel control unit.

4. Connect the special tool to the lead from the magneto generator.

Note A red tag should be connected to the special tool while the ignition is disabled as a reminder to remove the tool when the check is completed. An engine start cannot be made until the lead from the magneto generator has been reconnected to the ignition system microswitch receptacle on the fuel control unit.

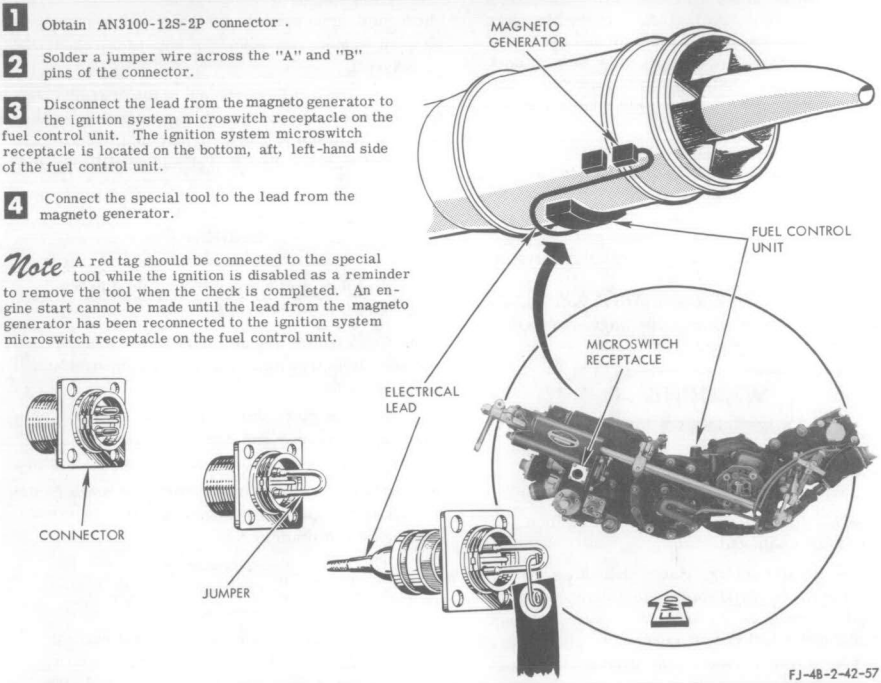


Figure No. 5-8. Special Tool for Disabling Ignition System

e. Check engine trunnion mounts for security. Make sure that trunnion mount clamp bolts have been properly safetied.

f. Check fire detector system. (Refer to paragraph 6-273.)

g. Remove all but one large restrictor in the tail pipe. Reinstall bolts in holes in tail pipe.

5-14. PRELIMINARY COLD RUN OF ENGINE.

5-15. Before the initial start of a newly installed or overhauled engine, the following procedures must be followed:

Note

The fuel control unit must be filled with fuel and allowed to presoak for at least 8 hours to condition all synthetic rubber parts prior to initial engine operation. This presoaking is not necessary if fuel control unit was presoaked prior to installation on the engine.

a. With the aid of a bright light, inspect the compressor first stage stator vanes and rotor blades for nicks, scratches or other evidence of damage. Check air intake duct for loose screws, rivets or foreign materials. This inspection is very important and should be carried out in a careful manner. Any small object drawn into the compressor section of the engine in this airplane could cause serious damage or even complete loss of the engine. When working in the intake duct, make sure that any object that is accidentally dropped is located immediately. Any time lost in hunting for a loose object in the intake duct will be time well spent.

b. Make sure that engine starter-generator cover is secured properly.

WARNING

Since it will be necessary for a man to enter the air intake duct to accomplish the preceding inspection, make sure, before allowing any crew member to enter the duct, that no one is in the cockpit of the airplane and that the external power supply is not connected to the airplane.

c. Place airplane in normal ground attitude, 7 degrees nose up, and place a guard screen over the air intake duct. Ensure that the danger areas around the intake duct and the exhaust tail pipe are clear of personnel, other aircraft, vehicles and debris and ensure that wheels are chocked. See figure 5-4 for danger areas fore and aft during engine run-up.

d. Connect a 1000 (+100/—0) ampere (constant current) 35-volt d-c external power source (rectangular-shaped receptacle) to airplane. A 28-volt d-c (constant voltage) source with a minimum capacity of 500 amperes must be plugged into the other external power receptacle (oval-shaped) for electrical requirements other than starting.

e. With power control lever in "OFF" position, disable the ignition system through the engine access door on the bottom of the fuselage (figure 5-8).

WARNING

Make absolutely sure that the ignition system is made inoperative (figure 5-8). If the ignition circuit opens when the power control lever is advanced to 5 degrees above "OFF" position, combustion will occur.

f. Place ENGINE MASTER switch, located on the forward end of the left-hand forward console, at "MASTER." This switch energizes the aft fuel booster pump and opens the master fuel shutoff valve.

g. Make sure that power control lever is in "OFF" position.

h. Place manual fuel control switch (MANUAL FUEL CONT), located on the forward end of the left-hand forward console, in "PRIMARY" position.

i. Hold STARTER switch, located on the forward end of the left-hand forward console, at "START" position momentarily. If engine does not reach 11% rpm within 20 seconds, place STARTER switch at "STOP" position and investigate cause for slow start.

j. When engine reaches 11% rpm, move power control lever to "IDLE" position. If fuel flow does not reach 400 to 600 pph, place ENGINE MASTER switch at "OFF" and place power control lever in "OFF" position. Wait at least 3 minutes; then, repeat steps f. through h.

CAUTION

If required fuel flow is not obtained after two attempts, place the power control lever in "OFF" position, place ENGINE MASTER switch in "OFF" position and investigate reason for no fuel flow.

k. While engine is being operated with the starter, check for unusual noises in the engine such as rubbing or scraping sounds. Any sounds of this nature should be investigated.

l. After the fuel flow required in the preceding steps has been obtained, momentarily depress STARTER switch in "STOP" position and move power control lever back into "OFF" position. Fuel flow should immediately drop to zero.

CAUTION

If fuel flow does not immediately drop to zero, engine is not safe to start.

m. Check entire engine carefully for fuel, oil and hydraulic leaks, particularly in engine compartment and accessory sections.

n. Check to make sure that all fuel and oil drains from engine are open and draining properly.

o. Carefully check for oil leaks at all oil pressure connections on rear and center bearing metering pumps as well as the parting surfaces themselves and external lines to the rear bearings.

CAUTION

The preceding check is very important since the oil feed rate of the metering pumps is exceedingly low (approximately one drop of oil per second); a very small leak can materially reduce the oil flow to the affected bearing or may even starve the bearing completely.

p. After preceding checks have been accomplished, make sure that all engine control switches are in "OFF" positions.

q. Through engine access door on bottom of fuselage, remove special tool from magneto generator lead and reconnect magneto generator lead to the ignition system microswitch electrical connector located on the fuel control unit.

CAUTION

Make sure that the ignition system is made operative before a start is attempted as the ignition system will not function until the magneto generator lead has been reconnected to the ignition system microswitch mount on the fuel control unit.

WARNING

To prevent any possibility of a "hot start" or an explosion, always wait a minimum of 3 minutes before starting engine after preceding cold run has been accomplished. During the cold run of the engine, raw fuel is sprayed into the combustion chamber and this fuel must be allowed to drain from the airplane before another start is attempted. The airplane must be in a normal "at rest" or "tail down" position to ensure fuel drainage.

r. Check to make sure that starter-generator cover and engine air intake access doors are properly installed.

5-16. INITIAL START OF NEWLY INSTALLED ENGINE.

WARNING

Avoid prolonged ground operation within the 60 to 82% rpm range.

5-17. Make preoperational check (paragraph 5-12); then, open aft engine compartment fire fighting access door and have fire fighting equipment available. Proceed as follows to start engine:

Note

If the fuel lines to the fuel control unit have been removed for any reason, air must be bled from the unit prior to starting the engine. (Refer to paragraph 5-51.)

WARNING

Before starting engine, make sure that danger areas fore and aft of the airplane are clear of personnel, other aircraft, vehicles and debris and ensure that the wheels are chocked. Suction at the intake duct is sufficient to kill or seriously injure personnel drawn into (or pulled suddenly against) the duct. Danger aft of the airplane is created by high exhaust temperatures and blasts from the tail pipe. (See figure 5-4 for danger areas fore and aft of the airplane during engine run-up.)

CAUTION

Whenever possible, start and run up engine on a concrete surface to minimize the opportunities for dirt and foreign objects to be drawn into the compressor. Start engine with airplane headed as nearly as possible into the wind as a tail wind may increase exhaust temperatures and would aggravate an engine fire during starting.

a. Disconnect engine oil pressure indicating line at oil pressure switch and install a "T" fitting between this flexible line and the oil pressure switch. Connect an auxiliary oil pressure gage to the "T" fitting. This setup will provide a means of: (1) determining the engine oil pressure in psig and (2) checking cockpit oil pressure indicator operation.

Note

It is not necessary to preoil the engine after disconnecting and reconnecting the oil pressure indicating line for this test setup.

b. Connect a 1000 (+100/—0) ampere constant current 35-volt d-c external power source to the airplane. This unit should be equipped with one plug to mate with the jet starting receptacle. A 28-volt d-c constant voltage source with a minimum capacity of 500 amperes must be plugged into the other external power receptacle for electrical requirements other than starting.

c. Place power control lever in "OFF" position.

d. Place engine MANUAL FUEL CONT switch in "PRIMARY" position.

e. Place ENGINE MASTER switch at "MASTER."

CAUTION

Do not move the control stick until the engine speed stabilizes at idle rpm. Movement of the control stick results in the directing of hydraulic pressure to the control surface actuating cylinders and imposes undesirable loads on the engine during the starting cycle.

f. Place d-c power switch at "OFF" position.

g. Hold engine STARTER switch momentarily at "START."

CAUTION

The high current required for starting will burn out the starter within a few seconds if the engine does not begin to turn as soon as the starter is energized. If there is no audible indication of engine rotation, or if the tachometer fails to register within a few seconds, move the STARTER switch to the "STOP" position immediately. If engine does not reach 11% rpm within 30 seconds after actuating the starter switch, position the switch at "STOP" and investigate.

h. At 11% rpm, move power control lever to "IDLE" position. This action opens the engine shutoff valve and starts the ignition cycle. Observe exhaust temperature indicator for signs of ignition.

WARNING

- If ignition does not occur within approximately 15 seconds after moving the power control lever to "IDLE" position, place the power control lever in "OFF" position, place engine STARTER switch to "STOP" and make sure that all surplus fuel has drained before attempting another start.
- If idle rpm is not attained within 120 seconds after moving the power control lever to "IDLE," abort the start by moving the power control lever to the "OFF" position and the STARTER switch to the "STOP" position. Before another start is attempted, investigate the following:

  1. Proper starting power of controlled 1000 amperes, 33 to 35 volts.
  2. Power lead connections.
  3. Proper starter-generator installation.
  4. Fuel control unit for correct settings and line connections.
  5. Excessive engine friction.

CAUTION

If the engine fails to start after two starting attempts, the starter motor and ignition system must be allowed to cool for a minimum of 30 minutes. If the engine fails to start on the next attempt after the 30-minute cooling period, the starter and ignition system must be allowed to cool for an additional 30 minutes before another start is attempted.

WARNING

During the engine starting procedure, the following hot start limits must be observed. If the exhaust gas temperature reaches or exceeds the hot start limit of 900°C (910°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197), the engine should be immediately stopped and given an overtemperature inspection. If the exhaust gas temperature exceeds 800°C five times, the engine must be given an overtemperature inspection. (On engines incorporating Engine Bulletins 195 and 197 or 196 and 197, if a total of five starts is made in which exhaust gas temperature exceeds 810°C but is less than 910°C or if temperature at one start exceeds 910°C, a special inspection is required. If one acceleration exceeds 810°C, a special inspection is required.) Log the duration and peak temperature on each start where the exhaust gas temperature exceeds 800°C (810°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197).

Note

- A normal starting procedure is recommended. However, with ambient temperatures above approximately 80°F, hot starts may sometimes occur if the power control lever is advanced directly to the "IDLE" position. Therefore, if the maximum exhaust gas temperature is anticipated or obtained, retard the power control lever toward the "OFF" position to reduce the fuel flow while monitoring the exhaust gas temperature. Advance the power control lever carefully to the "IDLE" position, monitoring the exhaust gas temperature to keep from exceeding the limit.
- The fuel flow can be monitored only from idle halfway to off. In the event of an rpm hang up, it is impossible to increase the fuel flow by positioning the power control lever above the "IDLE" position.

i. With the engine stabilized at idle rpm, external power should be disconnected and D.C. POWER switch positioned to "BAT. & GEN." Check the following operational limits: (1) The maximum exhaust gas temperature at idle should not exceed 660°C (670°C on engines incorporating Engine Bulletins 195 and 197 or 196 and

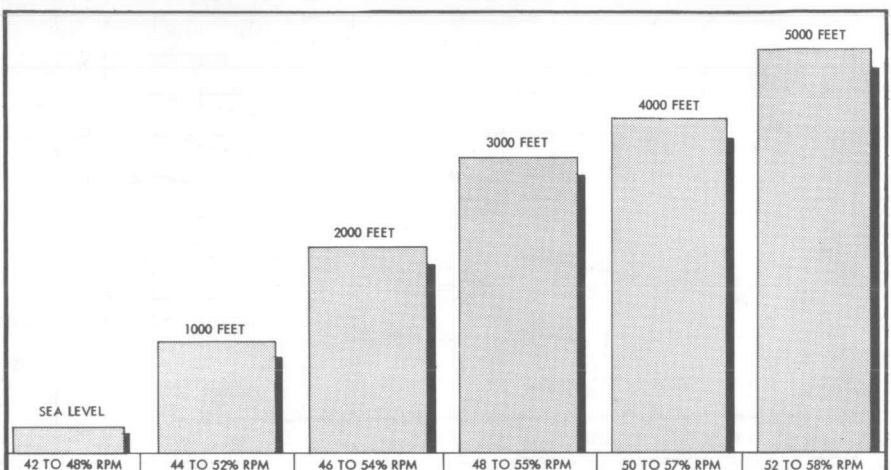


Figure No. 5-9. Manual Idle RPM Requirements at Various Ground Elevations

197). (2) The oil pressure indicator may read "LO" or "N." If an engine start is being attempted in extremely cold weather, the oil pressure indicator may read "HI" initially and the auxiliary oil pressure gage may read as high as 60 psig since the viscosity of the oil is affected by the ambient air temperature. However, this condition can be avoided if the engine oil system components are preheated prior to starting. (Refer to the following CAUTION.) The auxiliary oil pressure gage should read between 20 and 60 psig.

CAUTION

The oil pump and the oil tank must be preheated if engine is to be operated with the ambient temperature of −26°C (−15°F) or lower.

Note

The three-position oil pressure indicator, located in the cockpit, receives signals from an oil pressure actuated switch located on the engine. The switch is adjusted to function as follows: for increasing oil pressure, the N (normal) switch is actuated (closed) at 25 (±1) psig and the HI (abnormally high) switch is actuated (closed) at 38 (+2/−0) psig. For decreasing oil pressure, the HI switch will open at 40 (+0/−2) psig and the N switch will open at 25 (±1) psig.

Note

On FJ-4B airplanes 143543l and subsequent, a direct reading oil pressure gage calibrated from 0 to 70 psi is incorporated. When performing these checks, the cockpit oil pressure gage reading should be the same as the auxiliary oil pressure gage reading. If the readings are not the same, check out the oil pressure indicating system. (Refer to paragraph 6-304.)

CAUTION

- Engines operating on zero oil pressure for more than one minute but less than 2½ minutes must be inspected for the following:
  1. Normal engine run-down time.
  2. Oil pressure pump strainer and oil scavenger pump strainer free of metallic particles.
  3. No abnormal noise in engine.
  4. No indication of damage or metallization to engine.
- If zero oil pressure persists over 2½ minutes, engine must be removed.
- Engines operating on zero oil pressure for one minute or less are satisfactory for continued service.
- Time for this check should start with "motoring over" of engine.

(3) The engine tachometer indicator should read between 42 (minimum) and 48% (maximum) rpm.

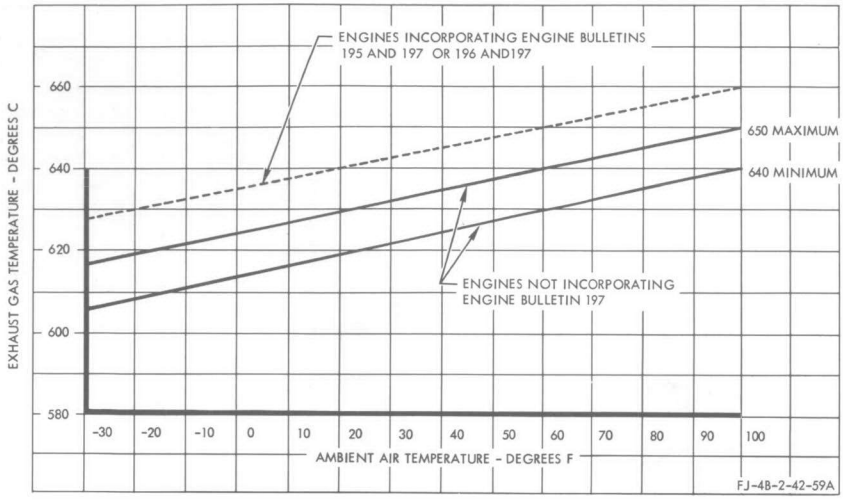


Figure No. 5-10. Exhaust Gas Temperature vs. Ambient Air Temperature at 100% Engine RPM

Note

If the "IDLE" stop on the power control lever is not within the preceding limits, check to ensure that the engine control system is adjusted in accordance with paragraph 5-41. Operate the engine with the aft face of the power control lever against the "IDLE" stop. With the engine running, turn the idle adjusting screw (located on the bottom of the engine fuel control unit) until a steady rpm between 42 and 48% is obtained.

(4) Generator output should be 27.7 (+0.5) volts dc.

j. Check operation of primer solenoid valve as follows: (1) With engine operating at idle rpm, momentarily place EMERGENCY IGNITION switch (located on left-hand forward console) in "ON" position. Observe fuel flow indicator for a sudden drop of approximately 100 pph.

CAUTION

Do not keep the EMERGENCY IGNITION switch in "ON" position for more than one second. If the emergency ignition switch is left on for a longer period of time, the engine may overheat.

Note

Fuel drainage from the engine overboard drain (located on the bottom of the airplane, slightly forward of the fuselage break) is normal during starting and should stop when the engine stabilizes at idle rpm.

k. While engine is at idle rpm, a check should be made to determine if primer solenoid valve is leaking. This may be accomplished by inserting a "T" fitting between the outlet side of the primer solenoid valve and the primers. Connect a 2½-foot hose with a spring-loaded valve to the open end of the "T" fitting. The check is made by opening the spring-loaded valve. Fuel should stop flowing approximately 5 seconds after valve is opened.

l. If engine operation seems rough, measure the vibration amplitude. The vibration amplitude may be measured with an instrument equivalent in accuracy to the MB Manufacturing Company's Model M6 engine vibration meter with Type 126 pickup. The maximum vibration amplitudes and pickup locations for the engine in a stabilized condition (steady state) are as follows: (1) Front main bearing support radially at the No. 1 strut location, 8 mils. This will be the only accessible pickup location if the engine is being run with the aft fuselage installed. (2) Combustion chamber rear flange vertically at the 12 o'clock location, 8 mils. This pickup location will be accessible only if the aft fuselage

is removed. (3) Rear flange of the compressor stator housing assembly horizontally at the 3 or 9 o'clock locations, 5 mils. This pickup location will be accessible only if the aft fuselage is removed.

m. Accelerate slowly to 85% rpm and check the following: (1) Exhaust gas temperature should not exceed 595°C. (2) Engine oil pressure indicator in cockpit should read "N" (normal). Auxiliary oil pressure gage should read between 24 and 40 psig. (3) Generator output should be 27.7 (±0.5) volts dc. (4) Auxiliary fuel tank air pressure should be between 7½ and 9 psi.

CAUTION

If the oil pressure indicator does not read "N" (normal) at this rpm, or if any doubt should exist as to whether the engine is obtaining proper lubrication, shut down the engine and investigate. With the use of the auxiliary oil pressure gage, check the oil line pressure to determine whether the trouble is in the oil system or in the indicating system in the cockpit. The auxiliary oil pressure gage should normally read between 24 and 40 psig.

n. Advance power control lever to 100% rpm and proceed as follows:

Note

- During this check, the engine rpm stop, located on the engine fuel control unit, and the exhaust nozzle area must be checked and, if necessary, adjusted. Care must be exercised during this check since the improper adjustment of the engine rpm stop can result in overspeed; the improper adjustment of the exhaust nozzle area can result in overtemperature.
- After obtaining 100% rpm, the engine speed may creep to a higher value. The maximum permissible engine speed is 101% rpm. If between 100 and 101% rpm is obtained with the power control lever short of the full power stop, or if less than 100% rpm is obtained with the power control lever against the full power stop, adjust the high-speed stop on the engine fuel control unit. (See figure 5-18.) Then, readjust the power control lever full power stop. (Refer to paragraph 5-41.)

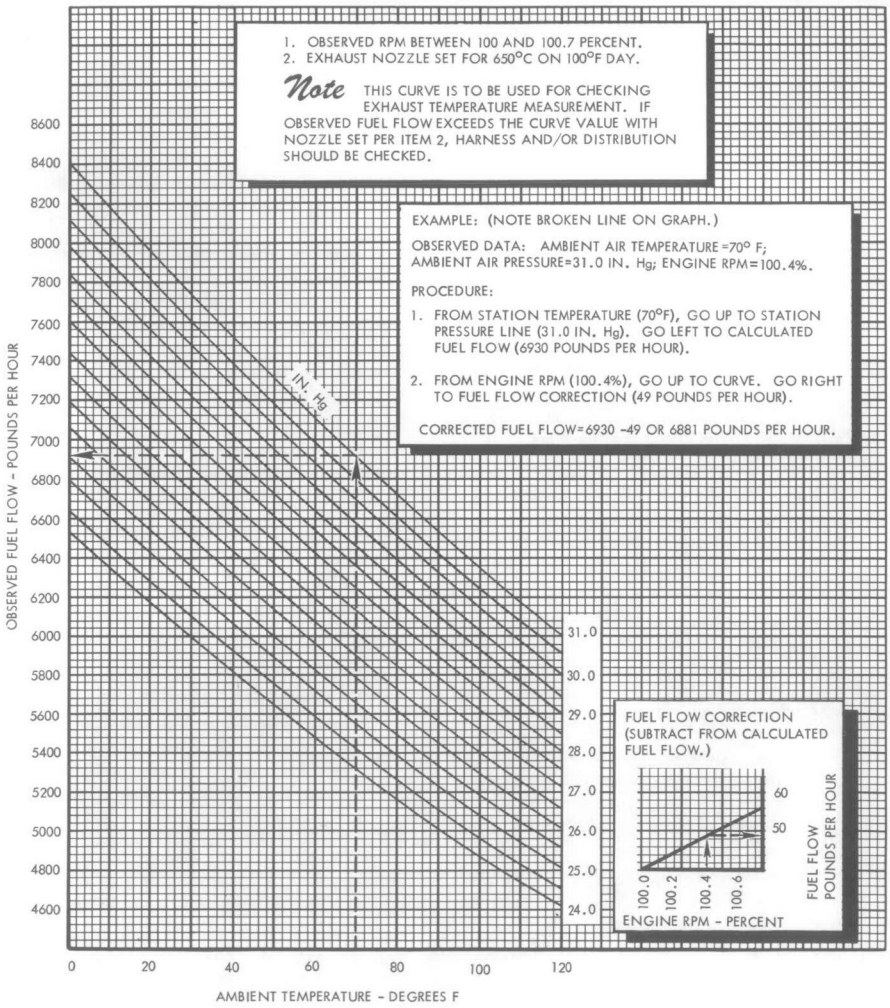
(1) Run engine for 3 minutes at 100% rpm prior to proceeding with check. (2) Exhaust gas temperature should stabilize between 640°C and 650°C (650°C and 660°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) on a 100°F (or hotter) day. (See figure 5-10 for maximum allowable stabilized full power exhaust gas temperature for other ambient temperatures.) (3) If, while power control lever is against the high-speed stop, exhaust gas temperature exceeds 650°C (660°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) after approximately 10 minutes of maximum power operation on a 100°F (or hotter) day, shut down engine and investigate reason for abnormal exhaust gas temperature. (Refer to paragraph 5-3.) (4) If correct exhaust gas temperature was not obtained, refer to paragraph 5-33 for tabbing the tailpipe nozzle area to obtain correct exhaust gas temperatures. (5) Generator output should be 27.7 (±0.5) volts dc. (6) Oil pressure should be normal ("N"). Auxiliary oil pressure gage should read not more than 40 psig.

Note

- Since oil pressure switch is set to read "HI" at 38 (+2/−0) psig, the indicator may read "HI" at 100% rpm. Check for maximum of 40 psig on auxiliary oil pressure gage if indicator reads "HI."
- If oil pressure is higher or lower than specified, run engine at 96% rpm and set main oil pump pressure relief valve to obtain 36 (+1/−0) psig; then, re-check pressure at various rpm settings as specified.

(7) Hydraulic pressure indicator should read approximately 3000 psi for each flight control system and the utility system. (8) Cockpit ventilating air supply from engine should not show presence of fumes. If excessive smoke appears in the cockpit, refer to paragraph 5-3. (9) See figure 5-11 for maximum fuel flow limits for various ambient temperatures and ambient air pressures.

o. After completing the 100% rpm check, make the following acceleration check. Run engine at 95% rpm or above for at least 5 minutes before performing acceleration check; then, proceed as follows: (1) Stabilize engine at 75% rpm for 15 seconds; then, advance power control lever as rapidly as possible to full power position. Note exhaust gas temperature. Acceleration time must be 5 seconds or less.



MAXIMUM FUEL FLOW LIMIT FOR J65-W-4B AND J65-W-16A ENGINES

FJ-4B-2-42-60

Figure No. 5-11. Maximum Fuel Flow Limit for Various Ambient Temperatures and Pressures for J65-W-4B and J65-W-16A Engines

WARNING

If an acceleration stall (identifiable by a severe rumble and rapid increase in exhaust gas temperature without appreciable change in engine rpm) is encountered during the acceleration, retard the power control lever immediately; then, advance the power control lever at a slower rate to the desired power setting. During any acceleration above idle speed, the exhaust gas temperature may attain a maximum of 800°C (810°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) for a maximum of 10 seconds. After the acceleration to the peak speed, the temperature must have stabilized at 650°C (660°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) or below. If these limits are exceeded one time only, perform an overtemperature inspection on the engine. If engine speed exceeds 106% rpm, shut down engine and perform an overtemperature inspection. If engine speed exceeds 108% rpm, engine should be sent to an overhaul facility. (See figure 5-10 for maximum exhaust gas temperatures at various ambient temperatures.)

(2) Make acceleration checks starting with the engine stabilized for 15 seconds at 65%, 60%, 55% and idle rpm. The maximum allowable time from idle rpm to 100% rpm is 15 seconds.

Note

If the maximum acceleration check is not made immediately following the foregoing acceleration checks, the engine must be operated for 5 minutes at 95% rpm or above prior to making the maximum acceleration check.

p. After completion of acceleration check, check manual fuel system as follows: (1) Set power control lever to an engine speed of 90% rpm. (2) Move engine MANUAL FUEL CONT switch, located on the left-hand forward console, from "PRIMARY" to "MANUAL." The manual fuel warning light, labeled "MANUAL FUEL CONTROL," should light.

Note

The engine speed will increase or decrease immediately, depending on how much the ambient conditions vary from standard. After switching to the manual system, advance the power control lever slowly, observing the exhaust gas temperature indicator. With the manual fuel system functioning properly, the following engine speeds should be obtained:

AMBIENT TEMPERATURE	RPM
100°F	99%
60°F	97%
0°F	92%

Note

The preceding engine speeds are minimum; higher values are satisfactory, provided 101% rpm engine speed or 650°C (660°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) exhaust gas temperature is not exceeded.

(3) Retard power control lever to "IDLE" and ensure that engine speed is between 42 and 48% rpm. (See figure 5-9 for idle engine speed settings at various ground elevations.) (4) With engine MANUAL FUEL CONT switch in "MANUAL" position, set engine speed at 90% rpm. Retard power control lever to "IDLE." Move the MANUAL FUEL CONT switch from "MANUAL" to "PRIMARY."

5-18. ENGINE SHUTDOWN.

5-19. To shut down engine, proceed as follows:

a. Run engine at idle rpm for one minute to allow exhaust gas temperature to stabilize.

b. Place power control lever in the "OFF" position and at the same time start a stop watch to record engine run-down time.

c. Record the engine run-down time. Run-down time should be longer than one minute. If run-down time is less than approximately one minute, investigate cause. (Refer to paragraph 5-3.)

d. Check for unusual noises in engine during shutdown.

Note

The ignition generator and the hydraulic pump gearbox (mounted on the No. 4 strut) will make considerable noise on engine shutdown. This must be taken into consideration when checking for unusual noises.

e. Check that oil pressure indicator drops to "LO."

f. Place all switches in "OFF" positions.

5-20. INSPECTION AFTER ENGINE SHUTDOWN.

5-21. After all engine run-up checks have been completed, inspect the engine installation as follows:

WARNING

Avoid looking down the exhaust tail pipe for some time after engine has been shut down as engines often belch hot gases shortly after shutdown. This is due to an accumulation of fuel in the bottom of the combustion chamber which may become vaporized and ignited in a stationary engine by hot combustion chamber surfaces.

a. As soon as possible after engine shutdown, refill oil tank to top of filler neck. Refer to paragraph 1-36 for oil tank servicing procedures.

b. Remove and inspect engine oil pressure and scavenge strainers located in oil pump.

c. Remove and inspect accessory gearbox scavenge oil strainer, located at the bottom of the accessory gearbox, and inspect externally mounted filter in return line to oil tank.

WARNING

If, after inspecting the above strainers, an accumulation of foreign matter such as metal chips, synthetic rubber, scrap or lint is found and the amount is excessive, replace the engine. If the accumulation of foreign matter is slight, clean and reinstall the strainers. The engine should then be run at 85% rpm for 5 minutes. If additional accumulation of foreign matter is found after the second run-up, replace the engine.

d. Remove, inspect, clean and reinstall main fuel filter (located on the engine fuel control unit) and the No. 4 fuel distributor screen.

WARNING

If a sizable amount of foreign material is found in the No. 4 fuel distributor screen, all other fuel distributor screens must be inspected and cleaned prior to further engine operation. If any fuel distributor is clogged to a point of collapse, engine should be subjected to a hot section inspection.

e. Inspect compressor entrance stator blades and first stage rotor blades by means of a bright light. Inspect blades and vanes for nicks, scratches or other evidence of damage.

WARNING

If evidence of oil leakage is indicated by wet compressor rotor and stator blades, perform an oil consumption check. (Refer to paragraph 5-3.)

f. Inspect the four generator cooling air outlets, located aft of the starter-generator cover on the center fairing, for evidence of carbon dust from the starter-generator brushes.

Note

If excessive carbon dust is found, further inspection of the starter-generator brushes is necessary. (Refer to paragraph 5-87.) If the brushes are worn excessively, remove and replace the starter-generator.

WARNING

In order to perform the foregoing checks, it will be necessary for a man to enter the air intake duct. All precautions must be taken to ensure that no one attempts to motor or start the engine while these checks are being made.

g. Inspect exhaust tail pipe for evidence of overheating, cracking and distortion. Check for freedom of movement of tail-pipe ball joint.

WARNING

If any evidence of distortion or damage to the tail pipe is present, refer to paragraph 5-22.

h. Inspect turbine wheel for missing blades or other damage.

i. Check engine control lever for freedom of movement over its full travel.

j. Inspect entire installation for evidence of oil, hydraulic fluid, fuel and exhaust gas leaks.

k. Check for fuel, oil and hydraulic line chafing, condition of electrical leads and general tightness and safety wiring of all nuts and fittings.

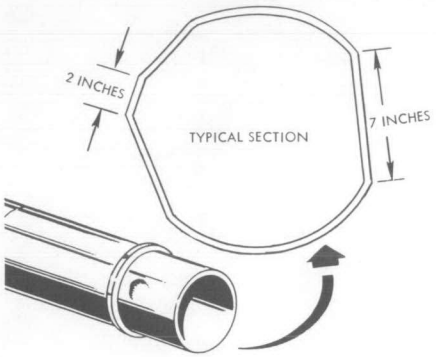
l. Service fuel system. (Refer to paragraph 1-34.)

5-22. INSPECTION OF EXHAUST TAIL PIPE FOR DENTS.

WARNING

Do not attempt to inspect the tail pipe until the engine has been allowed to cool after shutdown. An accumulation of drainage fuel in the combustion chamber may vaporize against the hot walls of the combustion chamber and belch hot gases out the tail pipe after the engine has been shut down.

5-23. The exhaust tail pipe should be inspected after each flight for creases, dents or cracks. Make this inspection on the interior surface of the pipe so that the exhaust pipe insulation blanket need not be removed. Remove blankets only if the internal inspection clearly indicates that an external check is necessary. The dents of primary concern are the circumferential (transverse) dents. A cross section through dents of this type is shown in figure 5-12. The bottom of these dents appears as straight line chords of the circumferential arc. The exhaust tail pipe must be replaced if the dents fall into any one of the following categories:



FJ-48-2-42-61

Figure No. 5-12. Exhaust Tail-pipe Dent Limits

a. Straight line bottom of dent is more than 7 inches long.

Note

This type of dent decreases the cross-sectional area of the exhaust tail pipe. For example, a 7-inch long dent on a 21-inch diameter tail pipe protrudes 5/8 inch into the exhaust stream.

b. Dent is shorter than 7 inches, but has sharp corners at the ends.

c. Two dents are on the same circumferential line and ends are less than 2 inches apart.

d. Two dents are not exactly on the same circumferential line, but are close enough to cause metal between the two ends of the dents to become "pinched."

e. A pattern of dents occurs closely adjacent to a circumferential weld. (This dent pattern reduces the column strength of the tail pipe and permits it to deflect at this point.)

Note

A number of dents or creases normally appear after the first few runs on every new tail pipe and remain relatively unchanged thereafter. These dents appear at random anywhere on the cylindrical surface of the pipe and are a result of a process in which the stresses resulting from fabrication are relieved. Unless the dents are large, or sharp in contour, they will have no effect on the service life of the tail pipe. It is required, therefore, that no attempt be made to bump out such dents if they will not "can" out with a simple push.

f. Replace tail pipe if any crack or puncture is found extending through the exhaust pipe skin.

Note

Repair of cracks is not permitted because of the extreme difficulties entailed in effecting a successful repair.

g. Replace or repair tail cone if a tail cone temperature thermocouple boss is cracked or broken.

5-24. TAIL CONE AND TAIL-PIPE INSULATING BLANKET REPLACEMENT CONDITIONS. Replace tail cone or tail-pipe insulating blankets for any of the following conditions:

a. Any cracks, punctures, or gouge marks in excess of 1/2 inch penetrating the outer foil.

Note

Pin holes (1/16 inch in diameter or less), dents or gouges on the outer surface are acceptable unless they form a pattern which would encourage cracking or failure of the foil.

b. More than two lacing hooks broken on the same edge.

c. Two broken lacing hooks side by side.

d. Two broken lacing hooks in the two end positions.

Note

- Lacing can be slightly rearranged to by-pass individual broken hooks.
- On blanket inner surface, pin holes and cracks are acceptable if cracks are less than 3 inches long and if adjacent edges of two cracks are more than 6 inches apart.
- Outer foil of blankets should present a shining surface.
- Scour any surface discoloration caused by burned oil, etc.

5-25. REPAIRING TAIL CONE AND TAIL-PIPE INSULATING BLANKETS. The following repairs can be made to the inner surface of the blankets using an H. I. Thompson 45-21144-110 welding kit or equivalent:

a. Holes from 1/16 to 6 inches in diameter.

b. Slits from 1/8 to 18 inches in length.

Note

- Numerous separate repairs not exceeding 25 percent of the total blanket area can be made.
- On aluminum staple-type blankets, repairs can be made to the outer surface of the blanket by removing the edge staples, opening the folded edge and inserting patch material. This material is to be stapled to the skin and the blanket reassembled.

5-26. ENGINE STARTER-GENERATOR COVER.

5-27. The engine starter-generator cover completely encloses the starter-generator and is mounted on the air inlet duct inner adapter. The cover is attached to lugs on the adapter ring on the air inlet duct inner adapter. Removal of the cover provides access to the starter-generator.

5-28. REMOVING STARTER-GENERATOR COVER. To remove cover, proceed as follows:

a. If engine is installed in airplane, enter at front of air intake duct and crawl back to access cover.

WARNING

Before entering air intake duct, make sure that all personnel working on the airplane are warned not to attempt an engine start.

b. Loosen cover retaining bolts.

Note

Do not remove cover retaining bolts. It is only necessary to slightly loosen cover bolts to free cover from brackets.

c. Pull cover forward to remove it from inner adapter.

5-29. INSTALLING STARTER-GENERATOR COVER. To install cover, proceed as follows:

a. If engine is installed in airplane, insert cover in to front of air duct first; then, enter air duct and crawl to location of starter-generator.

b. Fasten cover to adapter.

c. Fasten cover into place being sure to engage cover on air inlet duct inner adapter properly. Tighten cover retaining bolts to 35 to 50 inch-pounds torque.

5-30. ENGINE EXHAUST TAIL PIPE.

5-31. The exhaust tail pipe is fastened to a ball joint on the engine exhaust cone flange and terminates just forward of the opening in the rear fuselage; the tail pipe, like the exhaust cone, is covered by insulating blankets. Removable restrictors are provided at the aft end of the tail pipe for adjustment of the engine exhaust temperatures. The complete tail pipe is made accessible by the removal of the fuselage aft section.

5-32. REMOVING AND INSTALLING EXHAUST TAIL PIPE.

REMOVING

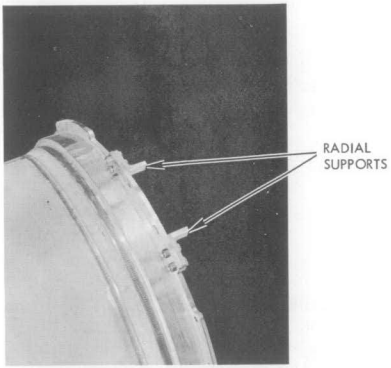
1. Remove tail-pipe radial supports.
2. Remove tail-pipe support links.

Caution Aft end of tail pipe must be supported to prevent damage.

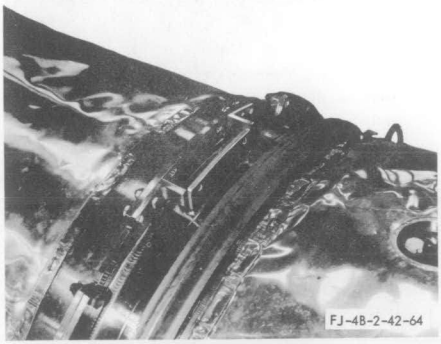
3. Remove tail pipe.

INSTALLING

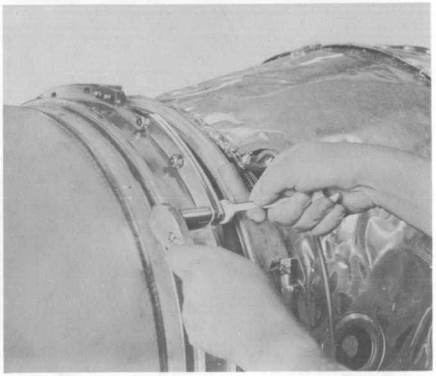
1. Install tail-pipe radial supports (right- and left-hand).

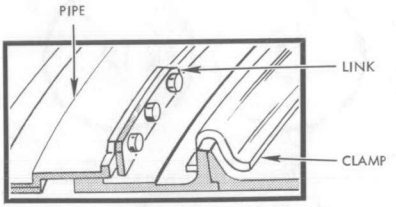


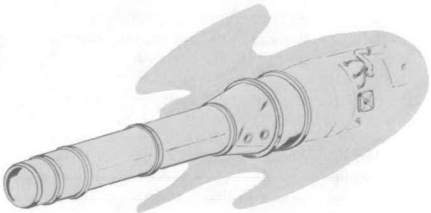
2. Install tail pipe. The tail-pipe radial supports must be located at the top of the tail pipe before the tail pipe is in the correct position for installation.



B. Install tail-pipe support links. Lubricate bolt threads with grease (item 8, materials list). Install cotter pins in bolts.







FJ-4B-2-42-65

5-33. ADJUSTING EXHAUST TAIL PIPE TO OBTAIN MAXIMUM OPERATING ENGINE TEMPERATURE.

Note

Perform Jetcal operational check of exhaust temperature indicating system before adjusting restrictor segments. (Refer to paragraph 6-244.)

Exhaust gases discharged through the tail-pipe nozzle create reaction thrust. Since the exhaust gases have both weight and velocity, the thrust can be varied by adjusting the tail-pipe nozzle area. The smaller the nozzle area, the higher the exhaust gas velocity, the exhaust gas temperature and the engine reaction thrust. The limiting factor which controls the smallness of the nozzle area is the maximum exhaust temperature at which the engine is permitted to operate. As tail pipes are made with a nozzle area of a predetermined size and it is known that operating characteristics will vary between engines, removable segment-type nozzle restrictor segments are provided for temperature adjustment. There are seven restrictor segments on the J65-W-4B and J65-W-16A engines. The segments provide a means of varying the nozzle area to obtain maximum operating engine exhaust temperature and, therefore, maximum thrust on all similar engine installations. The Jetcal analyzer is used for engine tabbing because engine speed and exhaust gas temperature are extremely critical during engine operation. Engine rpm can be checked to within ±0.1% rpm while exhaust gas temperature can be checked to within ±4°C. During engine run-up, all temperature readings are made on the Jetcal potentiometer since the exhaust gas temperature indicator is not accurate enough to be used during engine tabbing. The use of the Jetcal analyzer for engine tabbing will assure that the engine is operating at optimum engine conditions. To perform the engine tabbing procedure with the use of the Jetcal analyzer, proceed as follows:

a. Remove the exhaust gas temperature indicator from the instrument panel by loosening the tension screw at the lower right-hand side of the instrument and lifting the instrument free of the panel.

b. Disconnect the exhaust gas temperature thermocouple leads at the exhaust gas temperature indicator.

c. Connect the airplane thermocouple leads to the proper terminals of the switch box and connect jumper leads of the switch box to the terminals of the exhaust gas temperature indicator.

d. Connect the check cable to the switch box and to receptacle s-2 in the Jetcal analyzer.

e. Connect tachometer check adapter to instrument cable and instrument cable to Jetcal analyzer at receptacle P-3.

f. Remove tachometer indicator from instrument panel by loosening the tension screw at the lower right-hand side of the instrument and lifting the instrument free of the panel.

Note Restrictors must be positioned symmetrically about the vertical centerline. Restrictors may be positioned as symmetrically as possible about the horizontal centerline. However, if true symmetry cannot be obtained about the horizontal centerline, the extra restrictors must be placed on the lower portion of the tail pipe.

Install restrictors in sequence as shown.

Each large segment changes exhaust gas temperature approximately 20°C (36°F).

Each small segment changes exhaust gas temperature approximately 10°C (18°F).

Lubricate all screws with anti-seize compound (item 8, materials list).

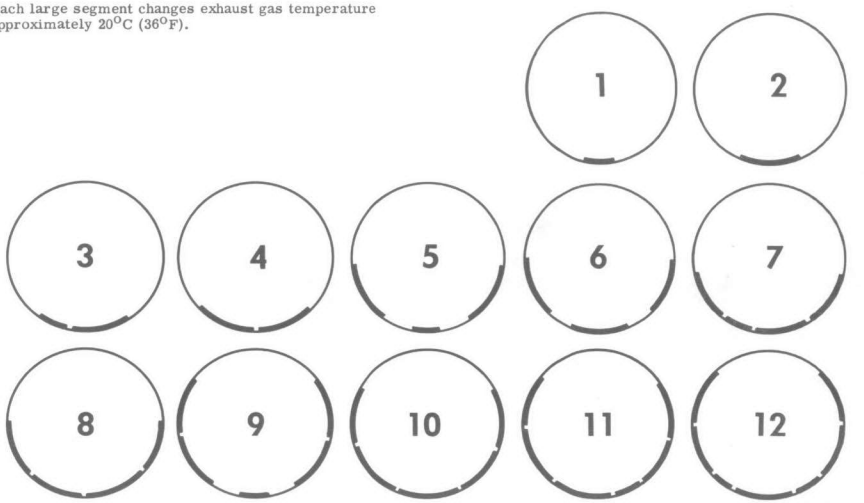


Figure No. 5-13. Placement of Exhaust Area Restrictor Segments—J65-W-4B and J65-W-16A Engines

g. Disconnect the receptacle from the tachometer indicator.

h. Connect the matching receptacles of the tachometer check adapter to the airplane's tachometer cable and tachometer indicator.

i. Connect power inlet cable to Jetcal analyzer at receptacle P-1 and to a 110-volt, 50- to 400-cycle, a-c power input.

j. Place SW-5 switch on the switch box in the "EGT" position. (Exhaust gas temperature indicator must be used on engine run-up to be able to detect a hot start.)

k. Install one large restrictor segment in the tail pipe in the position shown in figure 5-13.

l. Start the engine and advance the power control lever to 100% rpm.

m. Put SW-5 switch on the switch box in the "JETCAL" position and place SW-2 switch on the Jetcal analyzer in the "CHECK CABLE" position.

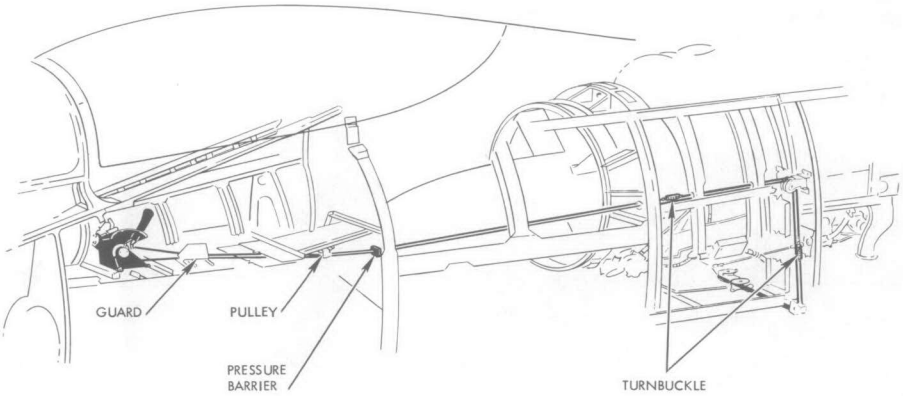
n. Record the exhaust gas temperature from the Jetcal potentiometer at one-minute intervals.

WARNING

- During any acceleration above idle speed, the exhaust gas temperature may attain a maximum of 800°C (810°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) for a maximum of 10 seconds. Thirty seconds after the start of the acceleration, the temperature must drop to 690°C or below. Ten minutes after the acceleration to the peak speed, the temperature must have stabilized at 650°C (660°C on engines incorporating Engine Bulletins 195 and 197 or 196 and 197) or below. If these limits are exceeded one time only, perform an overtemperature inspection on the engine. If engine speed exceeds 106% rpm, shut down the engine and perform an overtemperature inspection.
- If engine speed exceeds 108% rpm, engine should be sent to an overhaul facility. (See figure 5-10 for maximum exhaust gas temperatures at various ambient temperatures.)

o. Reverse sign of thermocouple harness error and add, algebraically, to the potentiometer reading to obtain true exhaust gas temperature. (To determine thermocouple harness error, refer to paragraph 6-257.)

p. Proper tabbing will be recognized when four stabilized exhaust gas temperature readings of the same value (three one-minute intervals) are within the ambient air temperature versus exhaust gas temperature curves in figure 5-10. If the exhaust gas temperature is not within these values, add or remove restrictor segments and repeat steps l. through o.)



Note Cables forward of turnbuckles remain with quadrant when quadrant is removed.

FJ-4B-2-43-1

Figure No. 5-14. Engine Control System

ENGINE CONTROL SYSTEM

5-34. ENGINE CONTROL SYSTEM.

5-35. Engine power is manually selected by a single power control lever which is located in a quadrant on the left console of the pilot's compartment. The power control lever is interconnected to the engine fuel control shaft by a cable system, a cable drum assembly and a push-pull rod system. (See figure 5-14.) The power control lever is held in the inboard position by spring action. Stops are provided in the closed, idle and full power positions to ensure positive action of the power control lever at these positions.

5-36. TROUBLE SHOOTING ENGINE CONTROL SYSTEM.

5-37. Refer to paragraph 5-3.

5-38. ENGINE CONTROL QUADRANT.

5-39. The engine control quadrant includes the power control lever and a friction lever mounted on the inboard side of the quadrant. (See figure 5-15.) The friction lever locks the power control lever at any desired position to prevent creeping. The friction lever may be adjusted by removing the lever and repositioning it on the serrated shaft. The power control lever handle incorporates a microphone switch, a speed brake switch, a radar range switch and a gun sight gyro cage switch. Rotating the handle approximately 25 degrees counterclockwise actuates the gyro cage switch and uncages the gyro. An adjustable catapult holding handle is mounted on the structure forward of the quadrant. The handle is spring-loaded and during catapult take-off is rotated to a vertical position and held along with the power control lever to maintain the full power position.

Figure No. 5-15. Engine Control Quadrant

5-40. REMOVING AND INSTALLING ENGINE CONTROL QUADRANT.

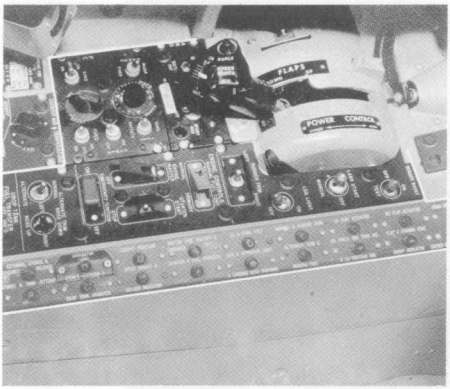
REMOVING

1 Through engine access door on bottom of fuselage, disconnect turnbuckle on engine control system cable.

2 Through left-hand engine access door, disconnect turnbuckle from engine control system cable.

3 Open gun bay access door, remove fasteners from shroud at top of gun bay to gain access to engine control cable seals and remove seals.

4 On forward section of left-hand console, remove wing flap control panel and all electrical switch panels including the left-hand circuit-breaker panel. The panels need not be removed completely, just unfastened and laid back.



5 With the panels removed, remove the guard from the engine control system pulley located beneath the armament switch control panel.

6 Remove the four bolts at the base of the quadrant. The nuts fastening the four bolts are located on the top side of the gun bay. The four bolts must be entirely removed before the quadrant can be lifted from the base.

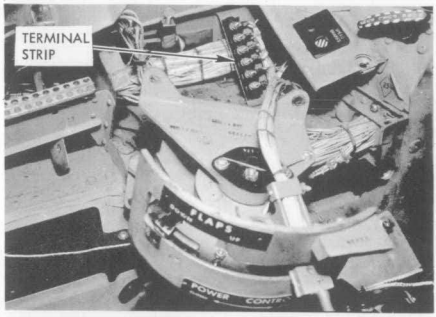
7 With the quadrant removed, disconnect the electrical leads in the power control handle from the terminal strip located forward of the base of the quadrant.

8 Completely remove quadrant from cockpit. The forward sections of the engine control system cables remain with the quadrant; the aft sections remain in the airplane.

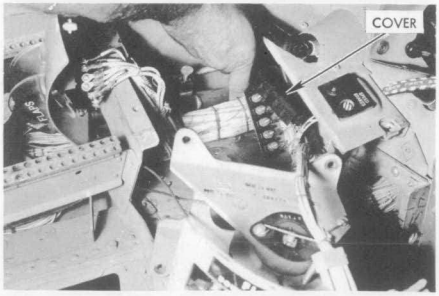
FJ-48-2-43-3

1 Thread cables through proper pulleys. (See figure 5-14.)

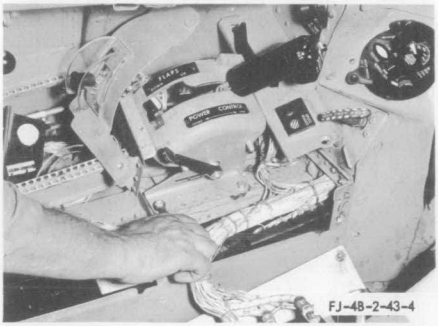
2 Connect electrical leads to terminal strip.



3 Place cover over terminal strip.



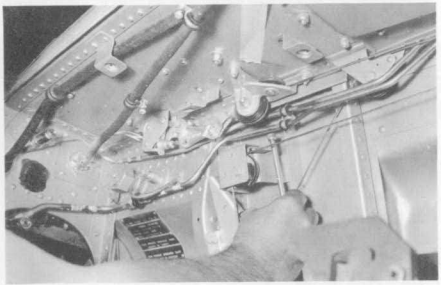
4 Position quadrant and insert bolts through holes in base.



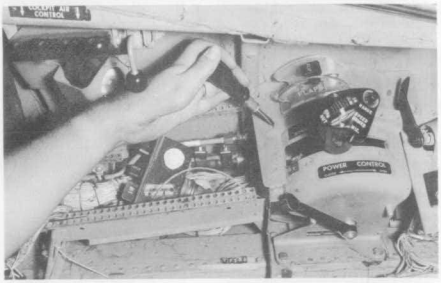
FJ-48-2-43-4

5 Open gun bay access door and remove shroud on top of gun bay to gain access to nuts.

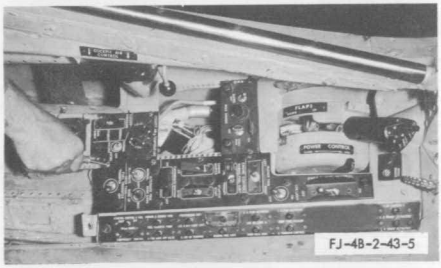
Note The nuts for the two outboard bolts are easily accessible. The two inboard nuts are not as accessible; therefore, the nut on the forward inboard side of the gun bay requires special care in installing the bolt. One method of installation is shown in the photograph. Insert nut on longer bolt and start threads on quadrant mounting bolt.



6 Install wing flap control switch panel.



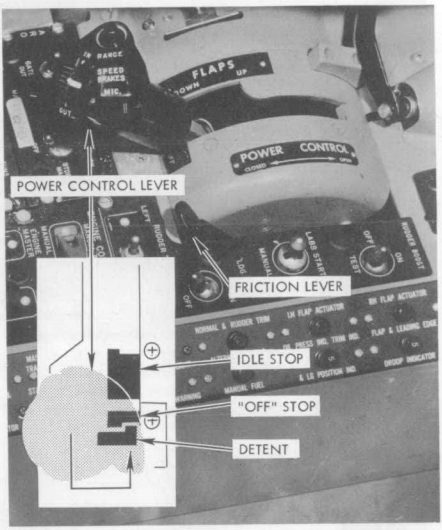
7 Install electrical switch panels and circuit-breaker panel on left console.



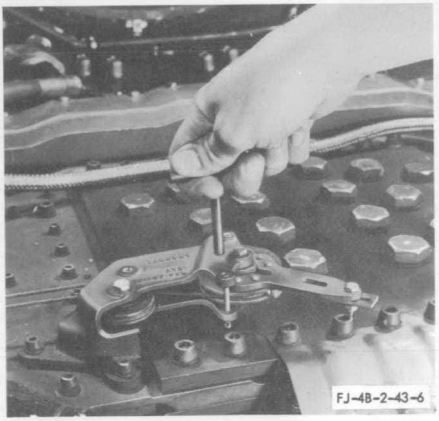
5-41. RIGGING AND ADJUSTING ENGINE CONTROL SYSTEM.

PRIOR TO INSTALLATION OF ENGINE

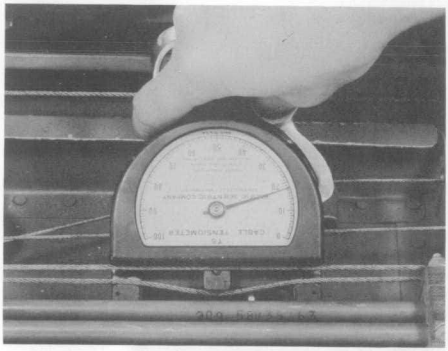
1 Move power control lever full aft, inboard and then forward against the "OFF" stop. Apply a slight amount of friction with the friction lever.



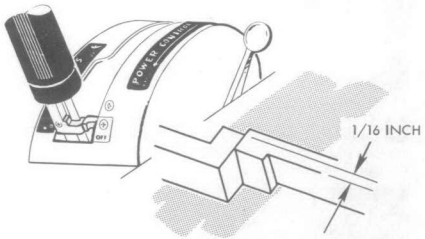
2 Line up rig pin holes in power control drum, located on deck of engine bay at station 203.8 and insert rigging pin through drum and bracket. Access to the drum bracket is made through lower engine access door.



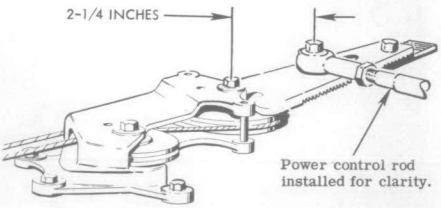
3 Adjust power control cables evenly to 45 (+ 5) inch-pounds load. If cables are tensioned properly, the rig pin can be removed and installed without binding. Access to the power control cable turnbuckles is through an access door located on the left-hand side of the fuselage aft of the cockpit and through the fuselage break with the engine not installed in the airplane.



4 Remove rig pin and move power control lever out of the "OFF" position to that shown. Lock with friction lever.

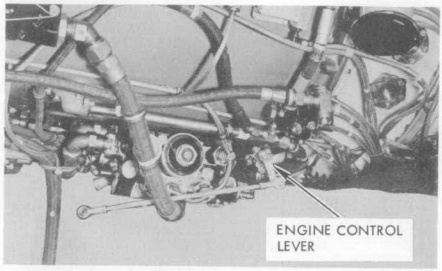


5 Set cable drum lever and adjusting plate to 2-1/4 inch length, center to center.



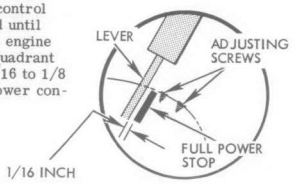
FJ-4B-2-43-7

6 With engine control lever in the "OFF" position, adjust power control rod to proper length and install. Determine that there is adequate cushion in the system to hold power control lever firmly forward in the "OFF" position when moved past detent and released.

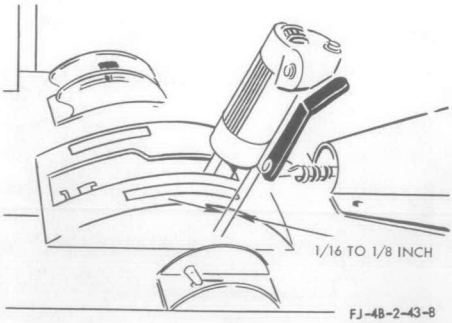


Note If total travel of power control lever is not approximately 1/2 inch greater than that required for full travel of the engine control lever, it may be necessary to readjust the cable drum lever and the adjusting plate (see step 5) in order to comply with all steps in these instructions.

7 Move power control lever forward until full power stop on engine is reached. Set quadrant full power stop 1/16 to 1/8 inch forward of power control lever.



8 Move power control lever fully forward against cushion in the system so that it touches the quadrant full power stop; then, adjust catapult handle to a clearance of 1/16 to 1/8 inch forward of the power control lever.



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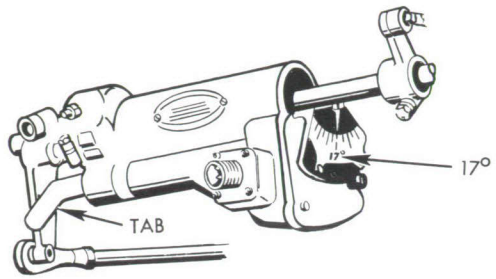
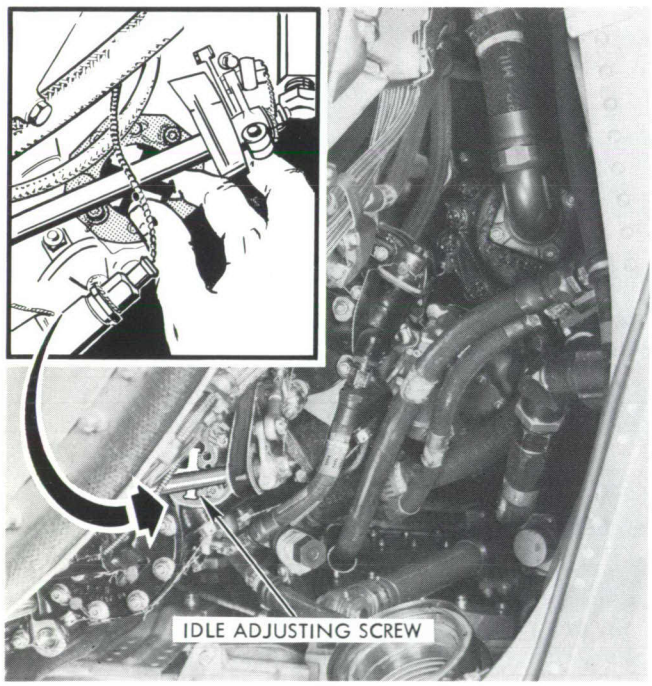
9 Move power control lever until engine control lever pointer indicates 17 degrees on engine fuel control index. Set "IDLE" stop on quadrant so that it rests against aft face of power control lever and lock in place. Check ignition system microswitch actuating tab for correct installation. If tab has been bent, ignition system will not function properly.



10 With engine running, turn idle adjusting screw (located on aft side of engine fuel control unit) until the correct idle rpm is obtained. (See figure 5-9 for correct idle rpm at various ground elevations.)



Note

- Friction lever may be adjusted by removing and repositioning lever on the serrated shaft.
- Prior to engine operation, advance power control lever full forward against full power stop and return to "IDLE" position. Move power control lever past the "OFF" stop to its maximum aft position and return to "IDLE." Check that the engine throttling control lever pointer indicates 14 to 17 degrees on the engine fuel control unit index after each return to "IDLE" in order to check for correct function of system.

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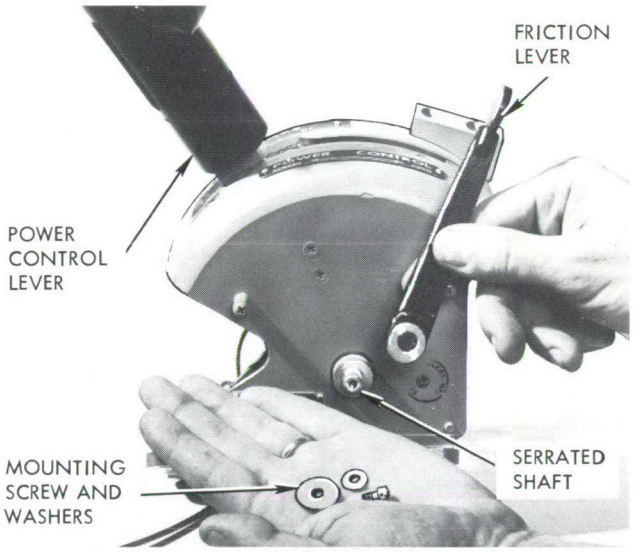
5-41A. ADJUSTING FRICTION LEVER.

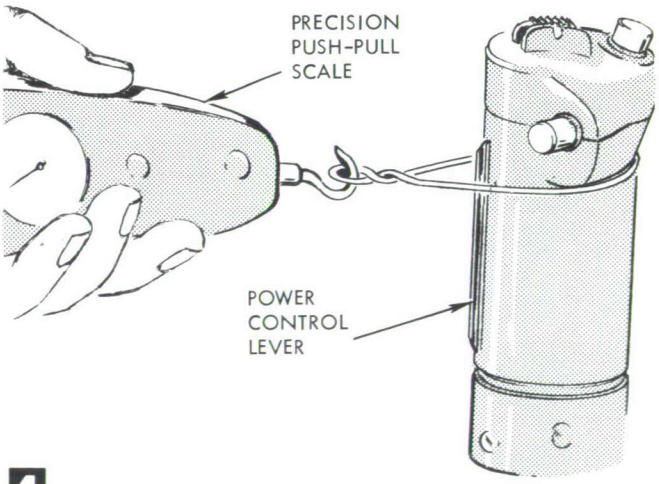
1 Loosen fasteners on left-hand console panel and lay panel back to allow access to the friction lever.

2 Cut safety wire and remove friction lever mounting screw and washers. Slide friction lever off of serrated shaft.



3 Reposition friction lever on serrated shaft so that with friction lever full forward the power control lever breakout force is 10 (±2) pounds.

Note Check power control lever breakout force, using a precision push-pull scale, by pulling perpendicular to the power control lever at a point just below the switch housing offset on the handle.



4 Reinstall mounting screw, washers and safety wire.

5 Reinstall left-hand console panel and secure fasteners.

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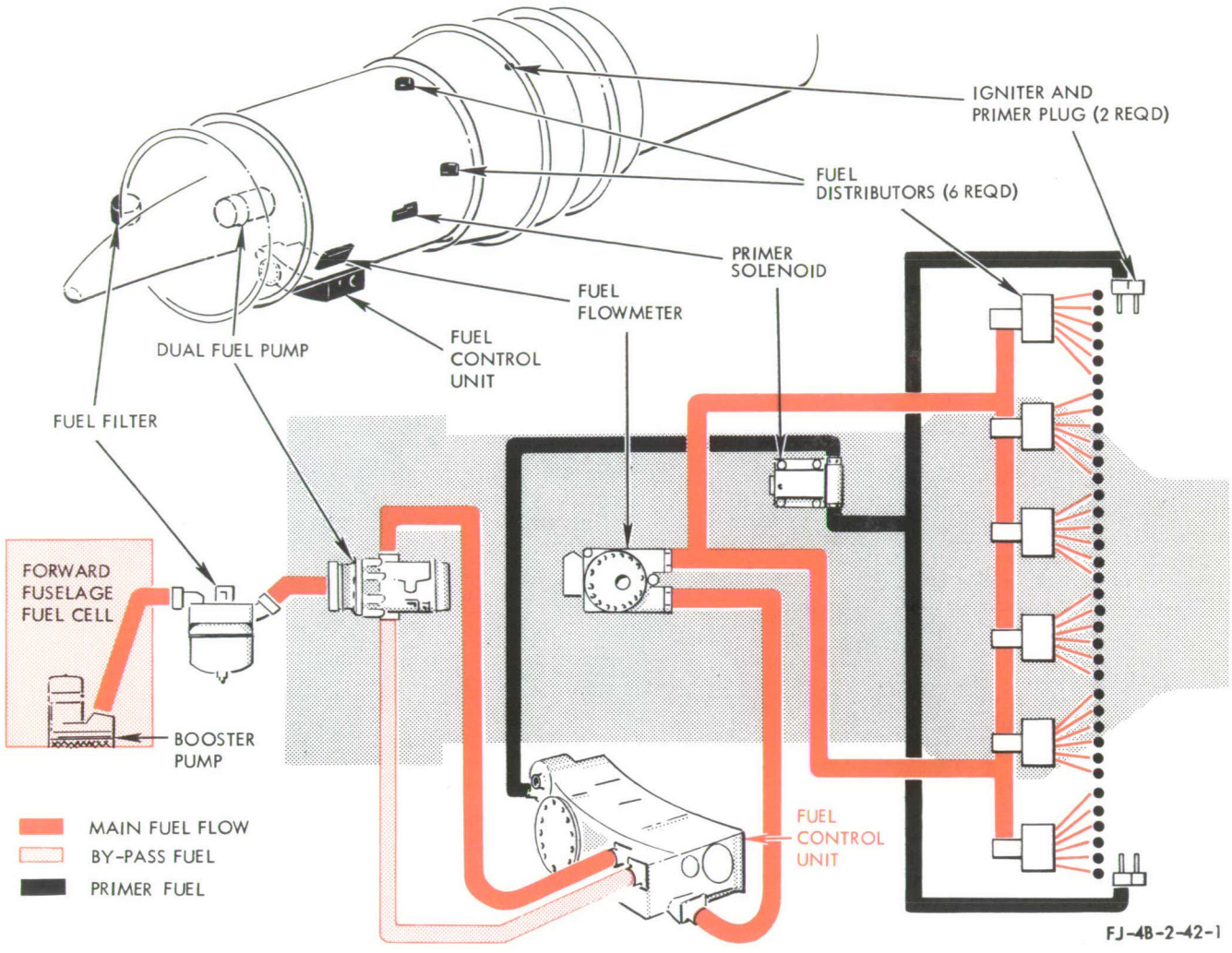


Figure No. 5-16. Engine Fuel System

ENGINE FUEL SYSTEM

5-42. ENGINE FUEL SYSTEM.

5-43. The engine fuel system (figure 5-16) regulates and injects the necessary quantity of fuel into the engine fuel system combustion chamber for proper engine operation. The system consists of the following components: an engine-driven, dual element fuel pump, a fuel control unit, an engine fuel filter, six fuel distributors, two fuel primer nozzles, 36 fuel tubes and a combustion chamber drain. A fuel flowmeter transmitter, which is used to give an indication of fuel flow to the pilot, is also a part of the system. (Refer to paragraph 6-311.) Fuel is supplied to the combustion chamber through the engine fuel filter, the engine fuel control unit, the six fuel distributors and the 36 fuel tubes.

5-44. FUNCTION OF ENGINE FUEL SYSTEM—PRIMARY OPERATION.

5-45. During primary engine fuel control, fuel enters the engine-driven fuel pump under booster pump pressure from the airplane's fuel system. The fuel output from the engine-driven pump is directed through a high-pressure filter, which is a component of the fuel control unit, and then flows into the fuel control unit where excess fuel is by-passed back to the pump inlet so as to maintain the required engine fuel pressure. The engine fuel is then directed through the cutoff valve and the pressurizing valve in the fuel control unit. From the fuel control unit the fuel flows to the fuel flowmeter transmitter, then to the six fuel distributors and finally to the 36 fuel tubes which supply the fuel to the combustion chamber where, after properly mixing with the compressor air, the fuel is burned. A small quantity of the fuel is directed to the primers for use only in the starting sequence.

5-46. FUNCTION OF ENGINE FUEL SYSTEM—MANUAL OPERATION.

5-47. Manual engine fuel control is provided by means of a simple throttle valve, across which the pressure drop is held constant by the same by-pass valve utilized in the primary engine control system. During manual operation, the fuel flow is regulated only by manual operation of the power control lever; therefore, altitude and airspeed compensation, acceleration control and deceleration control are not provided. Manual fuel system selection is made by a single solenoid-operated valve. When the valve is in the normally closed position, the inlet to the by-pass line of the manual fuel system is closed. When the solenoid is energized, the valve goes to the open position and the inlet is opened, permitting fuel to enter and by-pass the main body of the fuel control unit. Manual fuel system pressure against one side of the regulator valve operates a piston valve to hold the regulator valve in a closed position, thus blocking the passage of fuel into the main body of the fuel control unit during manual fuel system operation. Continuous electrical power is required to maintain operation on the manual fuel system. A two-position ("PRIMARY" for normal operation and "MANUAL" for manual operation) switch (MANUAL FUEL CONT), located on the left-hand console, and an emergency fuel control warning light (MANUAL FUEL CONTROL), located on the instrument panel, are provided. The warning light is energized whenever the MANUAL FUEL CONT switch is in the "MANUAL" position.

Note

The manual fuel control system solenoid can be energized when the d-c power switch is in either the "BAT. & GEN" or the "BAT. ONLY" position. The solenoid cannot be energized when the d-c power switch is placed in, or is passing through, the "OFF" position.

5-48. TROUBLE SHOOTING ENGINE FUEL SYSTEM.

Note

In the following trouble shooting chart, any references made to engine troubles such as engine failure to start, hot start, excessive exhaust temperatures, etc, pertain to engine troubles caused by failure of the engine fuel control unit. Consult the trouble shooting charts of the other engine systems given in this handbook if the cause of the trouble is not an engine fuel control unit failure.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
EXTERNAL LEAKAGE OF ENGINE FUEL CONTROL UNIT.		
"O" ring packings leaking.		Be sure control unit has been properly flushed, filled with fuel and soaked at least 8 hours. If leakage is of a minor nature, replace "O" ring packing. Fill control unit with fuel and soak for an additional 8 hours.
Leakage at lines or fittings.		Tighten leaking parts; replace any packings used.
ENGINE WILL NOT START.		
Control unit improperly flushed and filled with fuel.		Refer to paragraph 5-14.
Engine control lever actuated microswitch not operating.	Switch should open after 5 degrees of engine control lever travel from "OFF."	Correct or replace.
Improper operation of normally closed solenoid valve.	Check normally closed solenoid valve for actuation. Check circuit for continuity and power to solenoid. Check Cannon plug connections to the solenoid for security of fitting.	Correct or replace.
Improper starting procedure.		Refer to paragraph 1-9.
IDLE SPEED ON EITHER PRIMARY OR MANUAL FUEL CONTROL SYSTEM TOO HIGH OR TOO LOW.		
Improper idle setting.	Check idle setting on fuel control. Setting will vary with operating condition, especially when using the manual fuel control system. (See figure 5-9.)	Correct.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
TEMPERATURE TOO HIGH DURING ACCELERATION.		
Control operating on manual fuel control system.	Check MANUAL FUEL CONT switch for proper position and electrical circuit for proper functioning. Check normally closed solenoid valve for actuation.	Reposition switch.
Enrichment cam or temperature compensating circuit out of adjustment.		Replace fuel control.
ENGINE WILL NOT OPERATE ON MANUAL FUEL CONTROL SYSTEM.		
Manual fuel control system solenoid valve not operating.	Check that manual fuel control system normally closed valve opens when solenoid is energized. Check solenoid circuit continuity and power to solenoid. Make sure that all electrical connections are secure.	
TAIL-PIPE TEMPERATURE, RPM OR FUEL FLOW FLUCTUATES ON PRIMARY FUEL CONTROL SYSTEM BUT NOT ON MANUAL FUEL CONTROL SYSTEM.		
Newly installed fuel control not properly flushed or soaked.	Operate engine at various speeds. Cycling from primary to manual system and back to primary several times will assure filling the control with fuel. Allow several hours of fuel control operation before checking too critically for fluctuation. (Refer to paragraph 5-16 for correct method of cycling from primary to manual system.)	
If regulator has been operating satisfactorily for some time, instrumentation may be faulty.	Check instruments for accurate indications.	
SLOW ACCELERATION SPEED OR FLUCTUATING ENGINE SPEED WHILE OPERATING ON PRIMARY FUEL CONTROL SYSTEM.		
Air in fuel control.		Bleed fuel control. (Refer to paragraph 5-51.)

5-49. ENGINE FUEL SYSTEM FUEL CONTROL UNIT.

5-50. The fuel control unit (figures 5-17 and 5-18) is a speed density-type fuel metering device with engine speed determined directly by fuel flow. The amount of fuel flow is dependent on the size of the orifice through which the fuel passes and the pressure drop, or metering head, across this orifice. In the fuel control unit, the orifice is established by positioning the all speed-type governor valve in its sleeve. Orifice size is further controlled according to engine speed by an enrichment cam that limits valve opening movement at low speeds. The metering head (pressure drop) is established by the diaphragm-operated regulator valve which is positioned as a function of engine speed and compressor inlet pressure and temperature. Both the delivery orifice and the

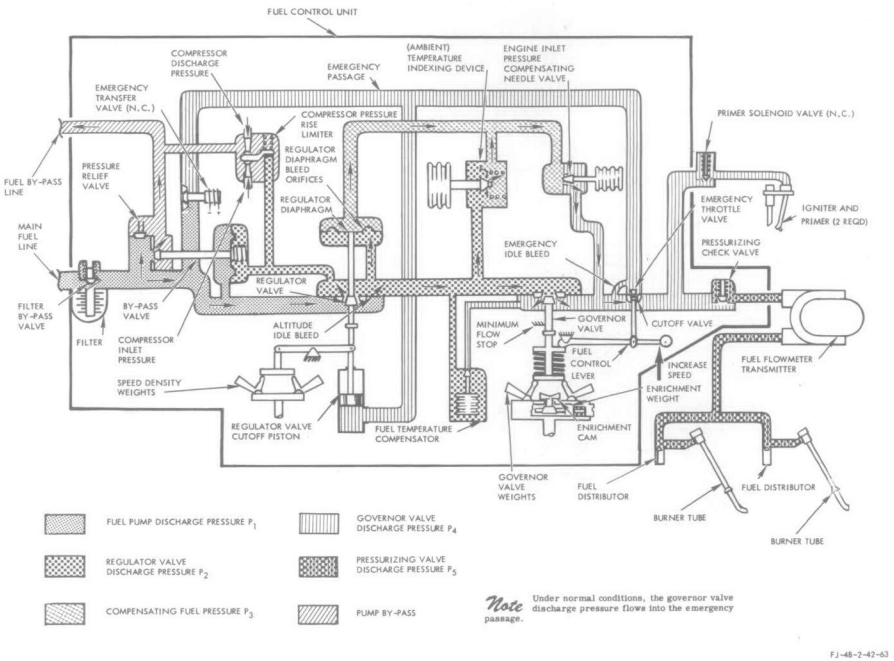


Figure No. 5-17. Engine Fuel Control Unit Schematic

metering head are variable. Operation of the fuel control unit can be explained by tracing fuel flow through the unit and indicating the forces that affect the flow. (For schematic diagram, see figure 5-17.) Fuel flows and pressures are designated as follows:

Fuel pump inlet pressure	P_0
Main fuel pump discharge pressure	P_1
Unmetered fuel pressure	P_2
Compensating fuel pressure	P_3
Metered fuel	P_4
Fuel manifold pressure	P_5

Fuel enters the fuel control through the main fuel filter in the filter by-pass valve and filter body assembly. The filter strains foreign matter larger than 80 microns in size from the fuel. If the filter becomes clogged, the filter relief valve opens to allow fuel to by-pass the filter and maintains a constant, unfiltered engine fuel supply. Excessive inlet fuel pressures in the control are prevented by the high-pressure relief valve. The valve opens when inlet fuel pressure reaches predetermined limits and diverts excess fuel and pressure back to the fuel pump. The by-pass valve maintains a relatively constant P_1-P_2 pressure differential during primary fuel control operation and the same differential across the emergency throttle valve during manual operation. P_2 pressure is sensed on the low-pressure side of the valve diaphragm; P_1 pressure is sensed on the high-pressure side of the diaphragm. When P_1 pressure exceeds P_2 pressure requirements, P_1 pressure against the regulator valve diaphragm opens the pressure relief valve to by-pass excess inlet fuel back to the fuel pump. A fixed bleed from P_2 pressure in the low-pressure side of the by-pass valve diaphragm reduces valve sensitivity and provides for rapid compressor pressure limiter response. The regulator valve establishes the metering head across the governor valve. Two forces determine the metering head that is established: the pressure differential between unmetered (P_2) and compensating (P_3) fuel pressures and the speed density weight force. The P_2-P_3 differential is acted upon by compressor inlet air pressure and temperature. The P_2-P_3 differential is a result of engine speed and is slightly affected by engine fuel requirements. P_2 fuel constantly bleeds to the altitude compensating section of

the P_3 circuit through fixed bleed orifices in the regulator valve diaphragm. P_2 fuel enters the temperature portion of the P_3 circuit through the temperature positioned enrichment valve and sleeve. Speed density weight force is proportional to engine speed and is determined by centrifugal head generating weights on the governor drive shaft. The weight force is transferred to the regulator valve stem through a suitable linkage and opens the regulator valve in proportion to engine speed versus P_2-P_3 regulator valve closing force. Compensating fuel pressure (P_3) is developed on the low-pressure side of the regulator valve diaphragm to modify P_2 fuel flow and maintain a fuel metering head according to engine speed and air density. Air density conditions are sensed at the engine compressor inlet by the temperature control and aneroid assemblies. These two assemblies act together, in series, to maintain a P_2-P_4 pressure drop proportional to engine speed and air density. The temperature enrichment indexing assembly indexes, or varies, the engine speed at which temperature enrichment is applied to acceleration fuel flows, according to sensed ambient temperature, to provide maximum engine acceleration while skirting the stall area. The higher the sensed inlet air temperature, the greater the engine speed, or P_2 fuel pressure, must become to move the regulator diaphragm and sleeve sufficiently away from the regulator valve to allow fuel under P_2 pressure to flow into the compensating circuit. A bellows in the temperature control assembly, acting through a plunger, locates the temperature enrichment valve in its sleeve after the enrichment valve opens. The valve is spring-loaded against the bellows plunger and the valve sleeve is mounted in a diaphragm controlled by P_2-P_3 pressure differential. Temperature compensating fuel flow is inversely proportional to sensed inlet air temperature at any given diaphragm position. Position of the temperature enrichment diaphragm is determined by P_2 pressure and a balance spring, applied on the high-pressure side of the diaphragm, acting against P_3 pressure and the enrichment diaphragm spring force on the low-pressure side. Prior to enrichment valve opening, the bellows, through the stop on the enrichment valve, positions the sleeve and diaphragm which, in turn, determine the force of the diaphragm spring. As engine speed increases, P_2 pressure increases, to overcome opposing forces, and moves the diaphragm and sleeve away from the enrichment valve. Fuel under P_2 pressure then flows through the opened enrichment valve to P_3 (compensating circuit) pressure. Increased P_3 pressure on the regulator valve diaphragm tends to permit the regulator valve to open, increasing the metering head across the governor valve and providing additional fuel for engine acceleration requirements. Bleed orifices, mounted in the regulator diaphragm, provide a constant source of fuel in the compensating circuit for the aneroid assembly. Altitude compensation is provided by action of an aneroid bellows that senses compressor inlet air pressure. The bellows moves a needle in its orifice to bleed P_3 fuel to P_4. The needle is positioned by bellows travel; as altitude increases, the bellows expands and draws the needle from its orifice to provide a larger bleed. As P_3 pressure on the low-pressure side of the regulator valve diaphragm is reduced through the aneroid bleed, P_2 pressure is correspondingly reduced; the regulator valve closes, as necessary, to maintain the P_2-P_3 differential. When the regulator valve closes, engine fuel supply is also reduced correspondingly. Additional engine fuel flow compensation is supplied, when fuel temperature is below 26.7°C (80°F), by the fuel temperature compensator incorporated in the aneroid assembly. Fuel under P_2 pressure is supplied to the well of the temperature compensator bellows and the head end of the hollow compensator needle through an external flex line from the main body P_2 pressure tap. One side of the orifice in which the needle operates is exposed to P_2 pressure; the opposite side is exposed to P_4 pressure. When the bellows moves, in response to fuel temperature, the hollow needle is positioned in its orifice and P_2 fuel flows past the needle directly to P_4. This fuel flow supplements normal P_2-P_4 fuel flow through the governor valve and increases the amount of P_4 fuel available to the engine at lower fuel temperatures. The orifice is closed, due to bellows action, at fuel temperatures above 26.7°C (80°F) and no fuel temperature compensation occurs above this temperature. The all speed-type governor valve establishes the orifice through which metered fuel (P_4) is delivered to the engine. Orifice size is varied by changing the valve positioning spring load that is applied to the valve from the pilot's throttle lever. The spring load opens the valve against the valve closing force of the centrifugal-type governor weights which are driven from the engine. When the spring load and weight forces are balanced, a governed fuel delivery orifice for a given engine speed is established. Acceleration fuel flows are obtained by loading the governor springs to overbalance the weight force and by moving the governor valve to establish a larger orifice. The larger orifice permits increased acceleration fuel flows until such time that the weight force overcomes and balances the spring load. Less fuel is required to maintain any given engine speed than to accelerate to that speed. Deceleration flows are obtained by removing all but the necessary idle spring load from the governor spring. The governor valve is closed by weight force until the valve contacts the minimum flow stop. At this point, the idle adjustment screw stop applies a slight, predetermined load to the governor spring. This slight preload requires a balanced governor weight force and establishes a governed orifice for idling fuel delivery. An enrichment cam in the governor drive shaft limits governor valve opening in the acceleration curve area which borders the engine compressor stall zone. Cam operation is timed according to engine speed to operate in conjunction with, but at a higher speed than, temperature fuel enrichment and to provide maximum safe acceleration. The cam is positioned by two opposed, spring-loaded pistons and racks in the governor drive shaft, operating on a pinion on the camshaft. The

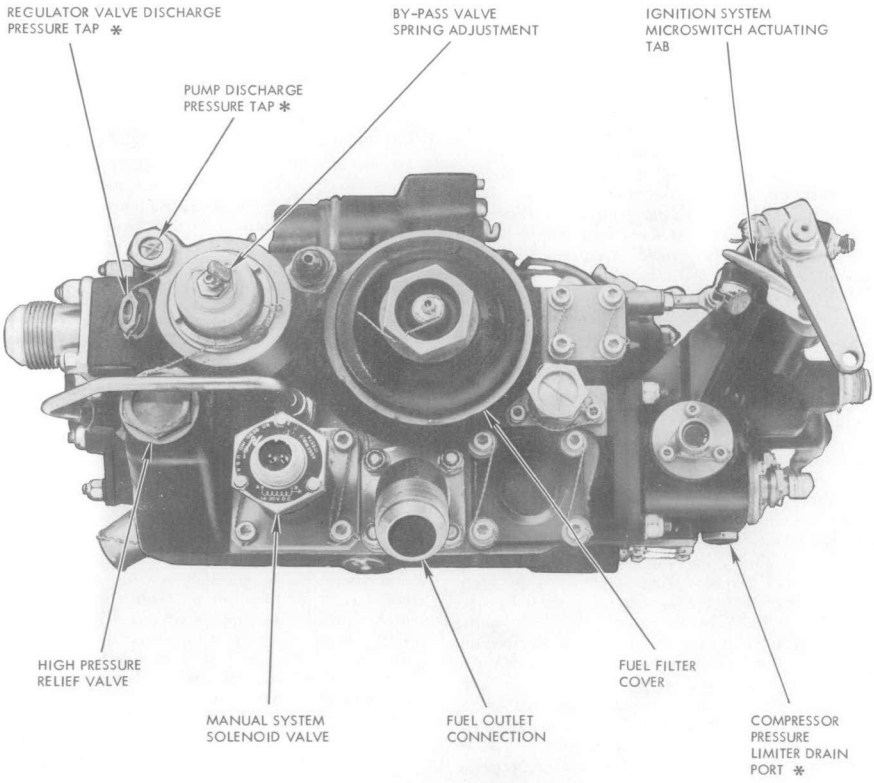
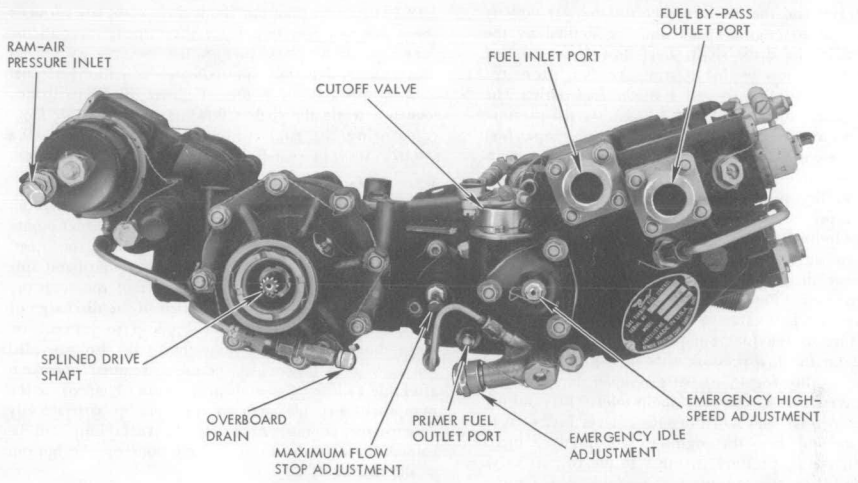


Figure No. 5-18. Engine Fuel Control Unit (Sheet 1)

FRONT VIEW



REAR VIEW

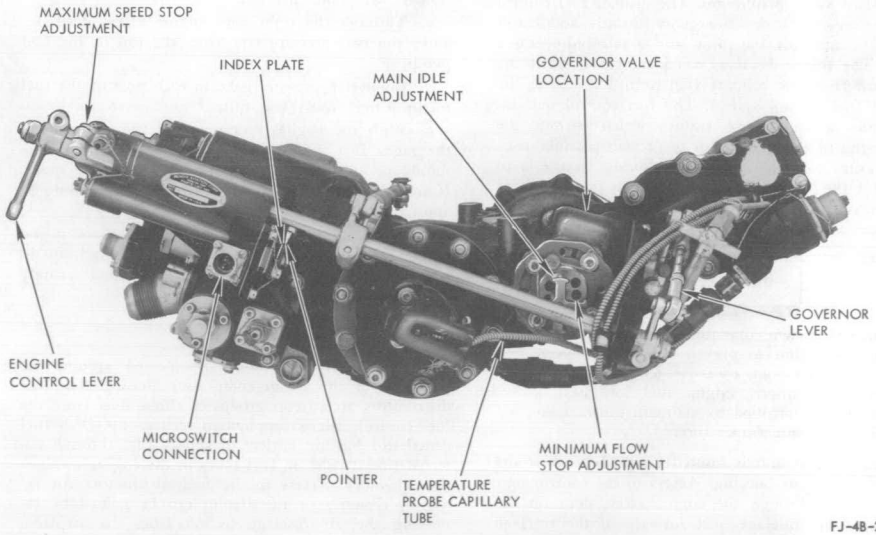


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Figure No. 5-18. Engine Fuel Control Unit (Sheet 2)

pistons are moved outward in their bores, against spring loading, by the centrifugal force resulting from drive shaft rotation; thus, the cam is rotated and the governor valve orifice is increased. The amount of piston travel and the resulting cam rotation are directly proportional to engine speed and are limited by the cam stop in the drive shaft. Fuel flow from the fuel control unit at low engine starting speeds is prevented by the pressurizing check valve in the fuel outlet. The valve will not open until 100 (+15/−0) psi pressure is built up in the fuel control unit to assure proper fuel flow to the engine priming circuit. During engine operation, the valve remains open to permit unrestricted fuel flow. Excessive engine combustion chamber pressures are prevented by action of the compressor pressure rise limiter assembly in the line from the P_2 pressure chamber to the by-pass valve. This unit senses compressor discharge and nacelle pressures. When a predetermined differential is reached between the pressures, the half ball valve in the assembly opens to bleed P_2 pressure to the fuel pump inlet. This decreases P_2 pressure on the low-pressure side of the by-pass valve diaphragm, allowing P_1 pressure to open the valve and divert excess fuel to the fuel pump inlet. The resulting decrease in inlet fuel and pressure reduces fuel flow to the engine and slows the engine to safe speeds. A bleed orifice in the P_2 pressure chamber to the by-pass valve line, ahead of the compressor pressure rise limiter, restricts fuel flow to the by-pass valve. This restriction helps the compressor pressure rise limiter assembly to rapidly reduce P_2 pressure on the low-pressure side of the by-pass valve diaphragm. The manual fuel control system consists of the emergency throttle and cutoff valves, operated by the pilot, and a solenoid-operated valve. The solenoid valve, when energized, shifts the fuel flow from the primary fuel control system to the manual fuel control system. The fuel control unit incorporates a monitoring feature which permits the monitoring of an engine start to prevent possible overtemperature conditions. This monitoring feature is in effect for the last 8 degrees of quadrant power control lever travel between the "OFF" position and the "IDLE" position.

WARNING

Manual system operation requires constant pilot attention to prevent engine overspeeding, rich blowout, excessive temperatures and similar conditions. Engine fuel flow must be manually controlled to maintain constant engine speed and temperature.

The fuel control unit is located on the bottom of the engine compressor housing. Access to the control unit can be made through the engine access door on the bottom of the fuselage, just forward of the fuselage break.

5-51. BLEEDING ENGINE FUEL SYSTEM FUEL CONTROL UNIT. To bleed the engine fuel system fuel control unit, locate the two pressure taps and the compressor pressure limiter drain port shown in figure 5-18. Turn each plug out about three complete turns or about one-half way out. Place the throttle lever in the "OFF" position, place the ENGINE MASTER switch in "MASTER" and permit approximately 2 gallons of fuel to flow through the pump. Tighten the plugs in any sequence while the fuel is flowing to prevent air from re-entering the fuel control unit. De-energize the ENGINE MASTER switch by placing in "OFF" position.

5-52. ENGINE FUEL SYSTEM FUEL PUMP.

5-53. The fuel system fuel pump is a combination, centrifugal boost and parallel dual gear-type fuel pump. The pump, which is engine-driven through the accessory gear box, is located on the lower right-hand side of the engine compressor housing, aft of the accessory gear box. Check valves are provided in the discharge of each main element of the fuel pump to prevent reverse flow. Separate shear sections are also provided for each gear element to permit continued operation after the failure of one element. Either element of the pump will provide sufficient pressure to satisfactorily operate the engine. Access to the fuel pump can be gained through the engine access door on the bottom of the fuselage.

5-54. CHECKING ENGINE FUEL SYSTEM FUEL PUMP. This check will determine if both eleme ts of the fuel pump are operating. To check the engine fuel system fuel pump, proceed as follows:

a. Through the right-hand engine access door, remove the two pressure taps from the top of the fuel pump.

b. Connect a pressure gage to each port of the fuel pump using AN837-4D fittings and extension hoses.

c. With the engine running, read the pressure on the gages. If a pump element is operating, the pressure should be approximately 250 psi at engine idle speed. If an element is not functioning, the pressure should be approximately 60 to 70 psi.

d. After check has been completed, remove gages, hoses and fittings from fuel pump and reinstall taps in ports. Make sure that the taps are installed securely and safetied.

5-55. ENGINE FUEL SYSTEM FUEL DISTRIBUTORS.

5-56. Six fuel distributors are located around the perimeter of the engine compressor housing. The fuel distributors are in two groups of three. Fuel from the fuel control unit is supplied to each group. Each fuel distributor has six outlets to supply fuel through external lines to the 36 fuel tubes in the engine combustion chamber. Access to the fuel distributors for removal, cleaning or installation can be gained by removing the aft fuselage section from the airplane. (Refer to paragraph 5-6.)

5-57. ENGINE FUEL SYSTEM FUEL TUBES.

5-58. Six fuel tubes are connected to each fuel distributor. These 36 fuel tubes supply fuel to 36 equally spaced fuel burners. Access to the fuel tubes can be gained by removing the aft fuselage section from the airplane. (Refer to paragraph 5-6.)

5-59. ENGINE FUEL SYSTEM PRIMER NOZZLES.

5-60. There are two primer nozzles which supply fuel to the combustion chamber during the engine starting cycle. These primer nozzles are located in conjunction with the igniter plugs. Fuel flow to the primer nozzles is controlled by a solenoid-operated valve which is a component part of the engine ignition system. (Refer to paragraph 5-106.) Access to the primer nozzles for removal or installation may be gained by removing the aft section of the fuselage. (Refer to paragraph 5-6.)

5-61. ENGINE FUEL SYSTEM COMBUSTION CHAMBER DRAIN.

5-62. The engine fuel system combustion chamber drain is located at the bottom of the combustion chamber. The drain permits drainage of fuel from the combustion chamber after a false start and of any fuel that remains after engine shutdown. The combustion chamber drain line is routed overboard through an opening on the lower left side of the aft fuselage section.

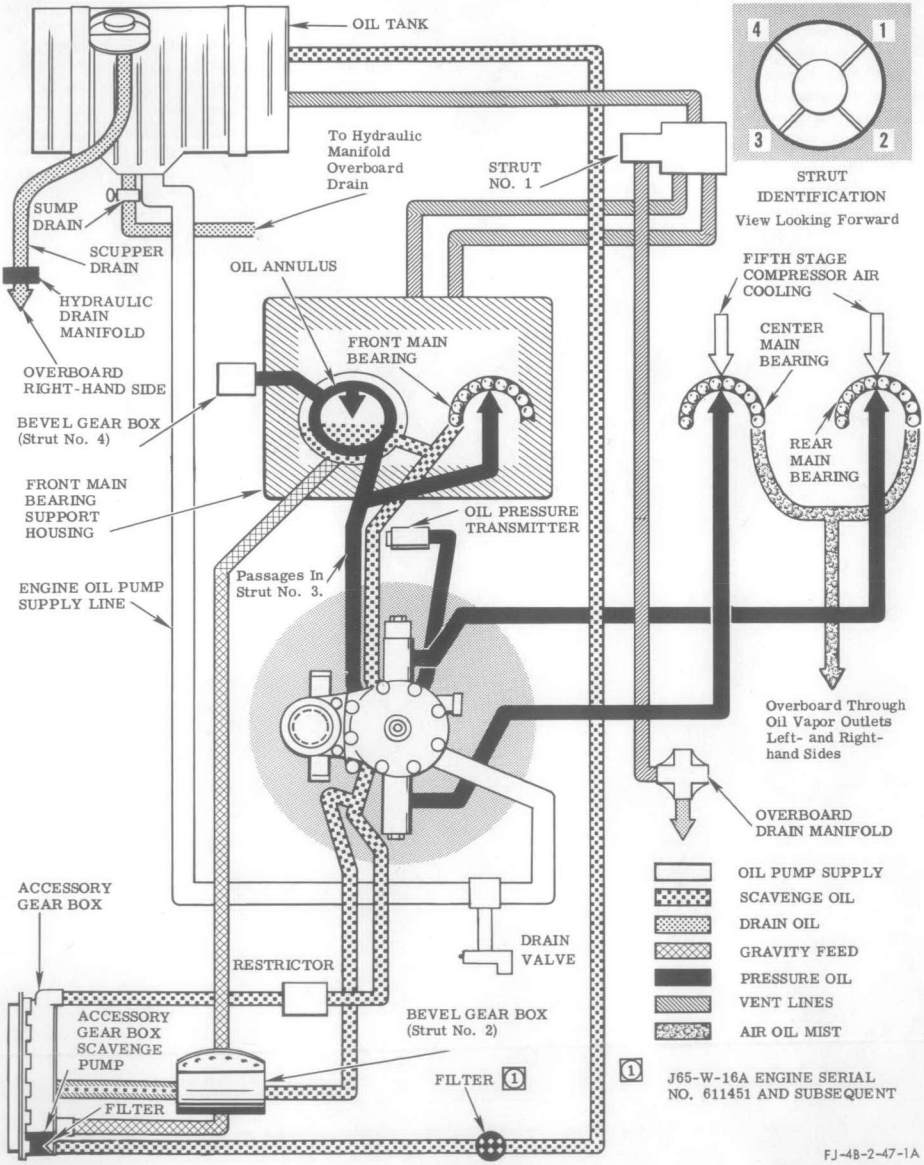


Figure No. 5-19. Oil System Schematic

OIL SYSTEM

5-63. OIL SYSTEM.

5-64. Lubrication for the engine is furnished by a dry-sump, pressure-type oil system. (See figure 5-19.) The system consists of an oil tank, a lube-and-scavenge pump and an accessory gear box scavenge pump. The oil tank is mounted on the right-hand side of the engine compressor housing. Oil flows from the tank through an external line to the oil pump located on the lower left side of the front main bearing support. An oil pressure indicating system is also provided.

5-65. FUNCTION OF OIL SYSTEM.

5-66. Oil enters the front main bearing support from the oil pump and branches off through two horizontal passages to two vertical passages in oil pump strut No. 3. The passage in the rear of the strut incorporates a metering plug and carries oil used to lubricate the front main bearing. The passage in the front of strut No. 3 carries oil to a mating passage in the accessory drive power take-off housing. Oil flows through this passage to an annulus in the center of the housing. From the annulus, one passage carries oil to a small jet in the housing where the oil is sprayed at the parts in the accessory drive power take-off housing. Two additional passages from the annulus mate with passages in front of struts No. 2 and No. 4. The oil passage in strut No. 4 is used to lubricate the gear box which drives the No. 1 flight control hydraulic pump. Part of the oil from the front main bearing and power take-off housing falls into strut No. 2 and flows into the bevel gear box to lubricate the gears by splash. The oil then flows by gravity through an external line, located at the bottom of the bevel gear box, to the accessory gear box where the oil is used as additional lubrication for the accessory gears. The remainder of the oil from the front main bearing and power take-off housing flows through an internal passage in strut No. 3 to the scavenge section of the oil pump. Oil from the scavenge section of the pump flows through an external line to the accessory section. This line divides into two lines: one line carries oil to an intake port at the top of the accessory gear box; the other line carries oil to an opening in the bevel gear box. From the bevel gear box, the oil flows through a hollow drive shaft, between the bevel gear box and the accessory gear box, and then flows into the accessory gear box. The oil from these two sources plus the oil which drains through the external line from the bevel gear box provides the lubricating oil for the accessory gears. This oil is picked up by the accessory gear box scavenge pump and is returned through an external line to the oil tank. The two metering pumps on the oil pump body supply oil to the center and rear main bearings. The pump on the top supplies oil in metered quantities to the rear main bearing; the pump on the bottom supplies oil in metered quantities to the center main bearings. In addition to oil supplied to the bearings, a quantity of air is bled from the 5th stage of the compressor to aid in cooling the bearings. The oil from the metering pumps and the air from the compressor flow through external lines as far as the center main bearing support housing. From this point, the oil and air flow through internal lines to the bearings. Internally, the two oil lines run through the inside of the two air lines; thus, air passing around the bearings and the oil passing through the bearings form a mist which is discharged out of the vapor manifolds on the center main bearing support housing and dumped overboard.

5-67. TROUBLE SHOOTING OIL SYSTEM.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
HIGH OIL CONSUMPTION.		
Oil line leakage.	Check all external lines for evidence of oil leakage.	Replace defective lines.
Clogged oil breathers.	Check breather system for obstruction.	Clean or replace lines.
Accessory seal leakage.	Check for leakage at accessories while engine is operating.	Replace accessory gear box assembly or replace defective oil seal.
Oil leakage past front bearing oil seals.	Inspect entrance and first stage rotor and stator blades for oil film.	If oil is present, replace engine.
Oil metering pump adjusted incorrectly.		Replace metering pump.
Faulty check valve in oil pump.		Replace oil pump.

PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
HIGH OR LOW INDICATED OIL PRESSURE.		
Faulty oil pressure indicator or oil pressure transmitter.	Check oil pressure indicating system. (Refer to paragraph 6-290 or 6-304.)	Replace oil pressure indicator or oil pressure transmitter if defective.
Oil supply insufficient.		Service oil system. (Refer to paragraph 1-36.)
Oil viscosity incorrect.	Check to make sure that correct oil is being used in system. (Refer to paragraph 1-36.)	Drain oil system and service with correct grade oil. (Refer to paragraph 1-36.)
Oil pump pressure relief valve adjustment incorrect.	Check adjustment on pressure relief valve.	Make correct adjustment on oil pump pressure relief valve.
Faulty oil pump.		Replace oil pump.
Internal oil leakage.		Replace engine.

5-68. OIL SYSTEM TANK (3-GALLON).

5-69. The oil tank is attached by two straps to the right side of the engine compressor section. Oil capacity of the tank is 3 U. S. gallons. The oil tank breather line and the scavenge return line are ported into the forward end of the tank. The filler neck is located on the aft end of the tank. The oil outlet is in the sump assembly in the bottom of the tank. The breather is vented to the front main bearing support housing on the engine by means of an external line. The tank has an internal feature which assures an adequate oil supply to the engine regardless of the attitude of flight. This mechanism is a hollow, pendulum-type chamber which rotates about an axle within the tank. The pendulum chamber is mounted off-center and is weighted at the bottom. A pipe at the top of the chamber provides a passage through the axle and a tube to the external breather port. The pendulum chamber also contains a tube which provides a passage through the axle and another tube to the outlet adapter well. In normal flight, a spring-loaded valve at the normal entrance from the tank to the oil outlet passage is held open by the bottom flange of the pendulum chamber. The pipe at the top of the chamber serves as a breather passage for air at the top of the tank. In inverted flight, the chamber rotates and the valve at the entrance to the oil outlet passage closes. Instead of flowing through this passage, oil flows through the chamber, the tube, the axle and tube in the tank and in to the oil outlet adapter well. With the airplane in an inverted attitude, the oil pump is above the tank outlet, but the pressure pump provides sufficient suction to draw the oil up into the pump.

5-70. OIL SYSTEM TANK (4-GALLON).

5-71. The oil tank is attached by two straps to the right side of the engine compressor section. Oil capacity of the tank is 4 U. S. gallons. The oil tank breather line and the scavenge return line are ported into the forward end of the tank. The filler cap is located on top of the tank, near the center. The oil outlet is in the sump assembly in the bottom of the tank. The breather is vented to the front main bearing support housing on the engine by means of an external line. The tank has internal features which help to maintain a sufficient oil supply to the pump, regardless of flight attitude. Flapper valves, incorporating counterweights, are used on the vent port and oil outlet adapter. These valves are repositioned by the counterweights so that the correct oil outlet and vent line port is opened, regardless of flight attitude.

5-72. REMOVING OIL SYSTEM TANK.

a. Remove engine. (Refer to paragraph 5-7.)

b. Drain oil tank. (Refer to paragraph 1-36.)

c. Disconnect sump drain hose at tank. Cap fitting in tank.

d. Disconnect oil outlet hose at tank. Plug hose and cap open fitting.

e. Disconnect breather hose at tank. Plug hose connection and cap tank opening.

f. Disconnect oil return line at tank. Plug hose connection and cap tank opening.

g. Remove bolts and washers and remove filler neck assembly. Install inspection plate on opening in tank.

h. Remove bonding wire from tank.

i. Remove lockwire from the two turnbuckles and back off turnbuckles to release oil tank support strap.

j. Swing tank away from compressor housing and remove tank from engine.

5-73. INSTALLING OIL SYSTEM TANK.

a. Place oil tank in position on engine and connect oil return hose before strapping down oil tank.

b. Bring straps into place and connect turnbuckles. Torque turnbuckles between 25 and 30 inch-pounds and safety with lockwire.

c. Connect sump drain line, breather line and oil outlet hose assemblies to tank.

d. Connect bonding wire to tank.

e. Remove inspection plate, if installed, and install filler neck assembly on tank.

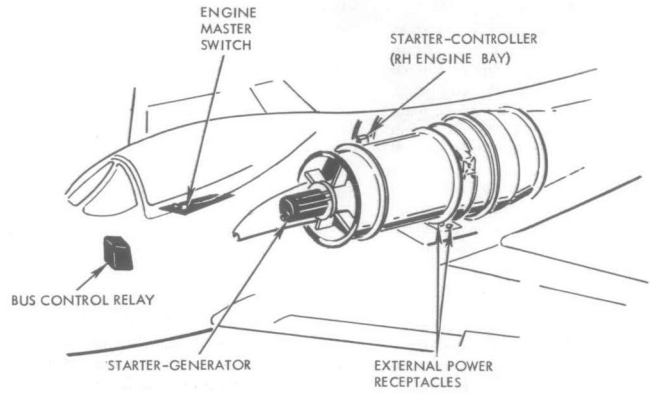
f. Service the oil system. (Refer to paragraph 1-36.)

5-74. OIL SYSTEM OIL PUMP.

5-75. The oil pump consists of one gear-type pressure pump, one gear-type scavenge pump and two piston-type or gear-type oil metering pumps. Oil is filtered through a strainer before passing into the engine. A circulating-type oil system is used for the front main bearing and accessory drives, and a total loss oil system is used for the center and rear main bearings. The oil pump is driven by the bevel gearing in the accessory drive power take-off housing located in the front main bearing support. The oil pump drive shaft passes through strut No. 3 and splines into the scavenge pump shaft. An intermediate gear on the scavenge pump shaft drives a camshaft gear which, in turn, drives the pressure pump gears. The camshaft actuates the metering pumps. Oil passes through the pressure pump and flows in two directions. In one direction, oil flows to the pressure relief valve; in the other direction, oil flows down through a passage in the oil pump center plate, past the check valve in the oil pump cover, up through another passage in the center plate and into the pressure pump strainer. When the engine is shut down, the check valve in the cover will close and prevent oil from flowing into the engine. When pressure in the pump builds up, excess oil is passed through an adjustable pressure relief valve and back in to the inlet side of the pressure pump gear cavity. From the strainer, one large passage carries oil to the front main bearing support to lubricate the front main bearing, the internal accessory drives, the bevel gear box, the No. 1 flight control hydraulic pump drive and to supply oil to the engine-driven airflow modulator oil pump in the front main bearing support. Another small passage from the strainer carries oil, through a series of passages, to the oil cover for the center and rear main bearing oil metering pumps. A third passage from the strainer carries oil to the bottom face of the pump body at the camshaft location to lubricate the camshaft bushing in the oil pump center plate. This passage also carries oil through a vertical passage in the camshaft to lubricate the camshaft bushing in the oil pump cover. A direct passage from the strainer cavity to the relief valve permits the relief valve to act as a pressure regulator for the by-passed oil during engine operation. Oil in the scavenge section of the oil pump passes through the scavenge strainer and flows through an external line to lubricate the accessory gear box.

5-76. OIL SYSTEM ACCESSORY GEAR BOX SCAVENGE PUMP.

5-77. The accessory gear box incorporates an internally ported scavenge pump. The pump consists of a pinion, a ring gear, a pump housing and a pump cover. The cover serves as an inlet cup. Oil enters through the inlet cup and flows through slots between the pinion teeth into the expanding spaces between the pinion and the ring gear teeth. Centrifugal force aids this flow of oil through the pinion slots. Compression starts as the pinion teeth are sealed by the inlet cup wall. The oil is discharged through an end-ported outlet located behind the inlet cup in the pump housing. Then, the oil is discharged through an external line to the oil tank. An oil filter is installed in this line near the scavenge pump on airplanes having J65-W-16A engines with Serial No. 611451 and subsequent. (Refer to paragraph 5-5.)



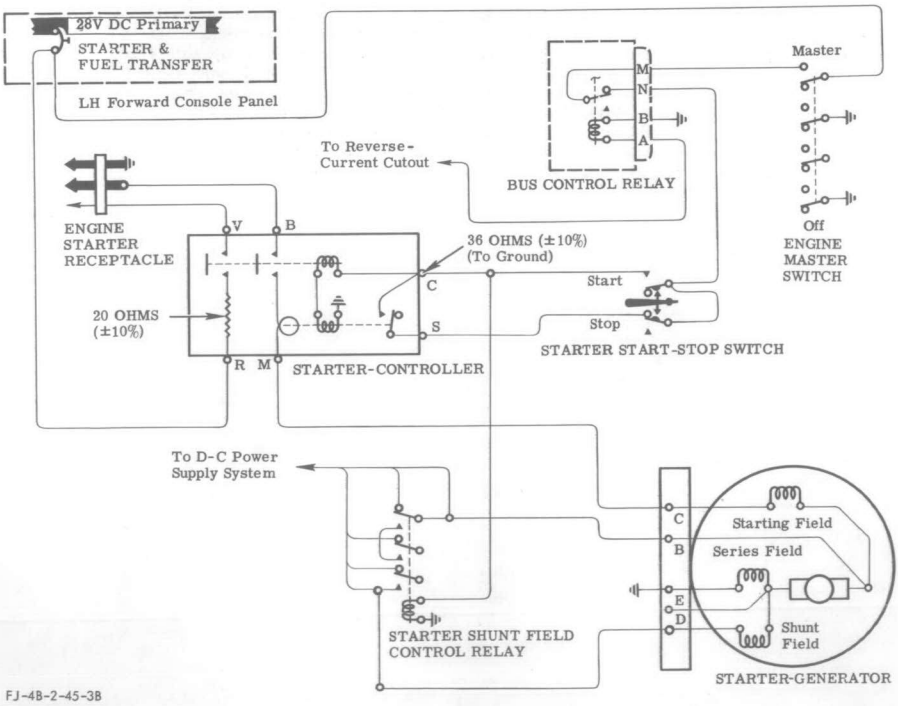


Figure No. 5-20. Engine Starting System Schematic

STARTING SYSTEM

5-78. STARTING SYSTEM.

5-79. The starting system (figure 5-20) is composed of the following units: a start-stop switch (STARTER), located on the left-hand console, which is a momentary three-position switch (the center or "off" position being the normal position), a starter-generator and a starter-controller. An engine master switch (ENGINE MASTER), located on the left forward console, is also used in the starter operation. Use of the starter-controller makes starter operation entirely automatic once the STARTER switch has been momentarily placed in the "START" position. The automatic starting circuit can be de-energized by placing the STARTER switch in the "STOP" position. This de-energizes the starter-controller relay and disconnects power to the starter-generator. The external power source for the engine starting operation should be capable of producing a 1000 (+100/−0) ampere constant current 35-volt d-c starting supply. Since the starter is energized by an external power source, the engine cannot be started by airplane battery power.

5-80. FUNCTION OF STARTING SYSTEM.

5-81. With an external starting power source connected to the airplane, the starting system functions as follows. When the ENGINE MASTER switch is placed to "MASTER" and the STARTER switch is momentarily placed in the "START" position, current flows through the starter-controller relay closing contacts which, in turn, connect the external power source to the starter winding through the series coil of the undercurrent relay. The initial surge of power energizes the undercurrent relay in the starter-controller which maintains the starter relay in an energized condition until the current flowing through the undercurrent relay drops enough to allow the undercurrent relay contacts to open. When the undercurrent relay contacts open (at approximately 22% rpm), power is removed from the starter relay and, consequently, power is removed from the starter winding. The starter-generator then operates as a generator.

5-82. ISOLATING TROUBLE IN ENGINE STARTING SYSTEM.

5-83. When the starter-generator does not operate, a trouble isolation procedure should be performed as follows:

a. With external power removed from the airplane, check the three Airtron fittings to the starter-generator for correct installation. Check the external power connectors for security of fitting. Check position of STARTER & FUEL TRANSFER circuit breaker located on the left-hand forward console.

b. If all Airtron fittings are installed correctly, check for possible engine seizure by manually turning the first stage compressor rotor blades to ensure that the blades turn freely.

WARNING

In order to perform the preceding check, it will be necessary for a man to enter the air intake duct. Make absolutely certain that no one attempts an engine start while the man is accomplishing this inspection.

c. If rotor turns freely, check for correct power requirements at the "C" lead of the Airtron fitting on the engine. Before connecting power to the airplane, slightly lift the lead connection in order to connect the positive lead from a voltmeter to the Airtron fitting. Connect the negative lead of the voltmeter to ground. Place the lead connection back firmly on the Airtron fitting and connect an external starting power source to the airplane. Place the ENGINE MASTER switch in the "MASTER" position and the STARTER switch in the "START" position. The voltmeter should read approximately 35 volts.

WARNING

Exercise caution when performing the preceding check. The external power source is rated at 1000 amperes and serious injury could occur to personnel coming in contact with the starter-generator lead during this check.

d. If the preceding check indicates a malfunction aft of the starter-generator, make an audible check of the starter-controller by having a man listen at the right-hand side of fuselage station 212 to determine if the contactors in the starter-controller close when the STARTER switch is placed in the "START" position and the ENGINE MASTER switch is in the "MASTER" position.

e. If there is an audible indication that contactors are closing in the starter-controller, check the 35-volt d-c external power source and receptacle for security of fittings, loose or defective wiring and proper output.

f. If there is no audible indication that the contactors are closing with the STARTER switch in the "START" position and the ENGINE MASTER switch in the "MASTER" position, check voltage across switch, armature and ground. If there is no voltage across the STARTER switch, trouble may be in an open circuit in the bus control relay or in the engine master switch. If the aft booster pump operates with the ENGINE MASTER switch in the "MASTER" position, the engine master switch is functioning properly and trouble must be in a defective bus control relay.

g. If voltage check made in step c. indicates that trouble is in the starter-generator, remove starter-generator cover and check for security of "E," "B" and "C" leads at terminal connections on starter-generator. If all connections are secure, remove starter-generator and check for dirty, rough or pitted commutator, shorted or grounded armature or brushes not seated properly.

h. If all components and wiring of starting system check out satisfactorily, replace starter-controller.

5-84. STARTER-GENERATOR.

5-85. A 500-ampere combination starter-generator is driven by the engine. This unit performs a two-fold purpose: it is used for cranking the engine and also to provide primary power for the electrical system of the airplane. The starter-generator will begin to produce power when the engine rpm reaches approximately 22% and will deliver rated power at approximately 36% rpm. Access to the starter-generator may be gained through the engine air intake duct.

CAUTION

If the engine fails to start after two starting attempts, the starter must be allowed to cool for a minimum of 30 minutes. If the engine fails to start on the next starting attempt, after the 30-minute cooling period, the starter must be allowed to cool for an additional 30 minutes before another start is attempted. Do not keep power on starter longer than one minute during any one start.

5-86. REMOVING AND INSTALLING STARTER-GENERATOR.

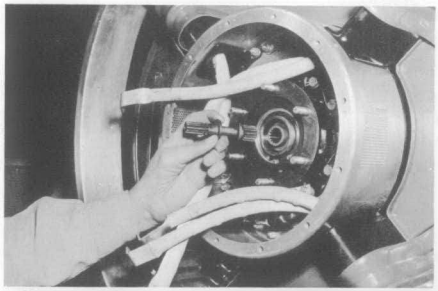
REMOVING

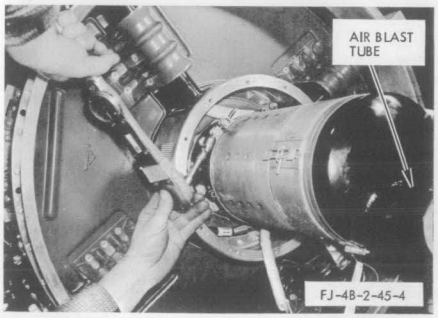
1. Remove starter-generator cover. (Refer to paragraph 5-28.)
2. Remove clamp from starter-generator leads.
3. Cut safety wire and remove starter-generator leads from terminals.
4. Loosen bolt on clamping ring.
5. Remove starter-generator by pulling straight out of adapter.

Caution Exercise extreme care in removing starter-generator. This unit weighs approximately 84 pounds.

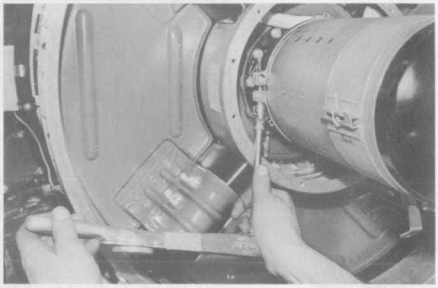
INSTALLING

1. Position starter-generator and stub shaft in mounting adapter. For proper installation, the starter-generator air blast tube must be at the six o'clock position.

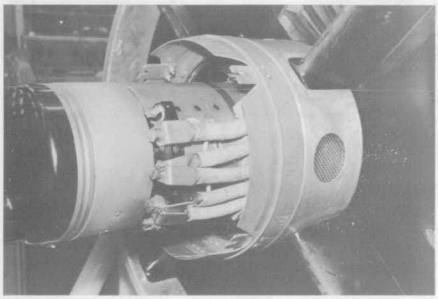




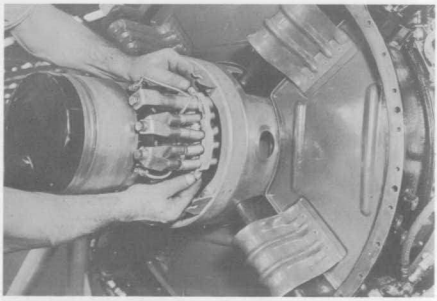
2 Tighten bolt on clamp ring. Make sure that ring is seated in groove before torquing. The 7/16-inch hex head clamp bolt must be torqued to 120 inch-pounds, then loosened one-half turn and torqued again until bolt ceases to advance.



3 Connect starter-generator electrical leads to terminals. Torque bolts 150 (±3) inch-pounds. Safety-wire bolts.



4 Install starter-generator lead clamp.



5 Install starter-generator cover. (Refer to paragraph 5-29.)

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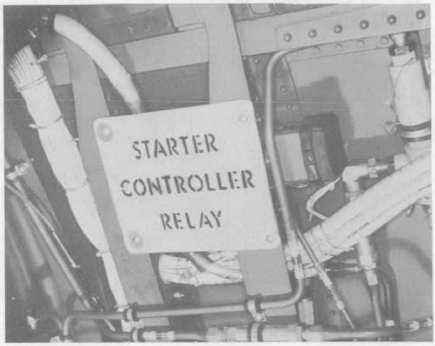
5-87. CHECKING STARTER-GENERATOR BRUSHES. If brushes are worn to more than 3/8 inch from top of brush box to top of brush clip, the starter must be replaced.

5-88. STARTER-CONTROLLER.

5-89. The starter-controller (figure 5-21), mounted within the engine compartment, connects external starting power to the starter for engine starting. The controller consists of two relays within one unit: a starter contactor relay and an undercurrent relay. The latter relay serves as a locking relay for the starter contactor during automatic starting of the engine. This type of starting eliminates the necessity of holding the starter switch closed during cranking. After engine reaches approximately 22% rpm, the starter-controller is de-energized and electrically disconnected from the starter. For function of the starter-controller, refer to paragraph 5-80.



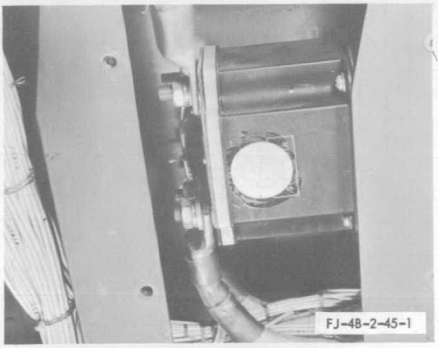
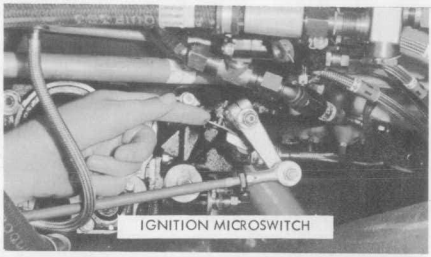
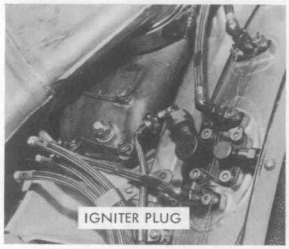
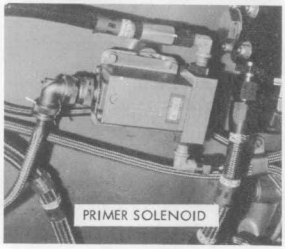
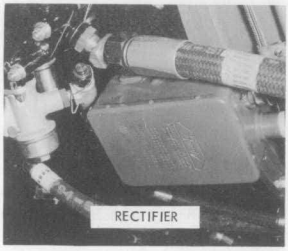


Figure No. 5-21. Starter-Controller









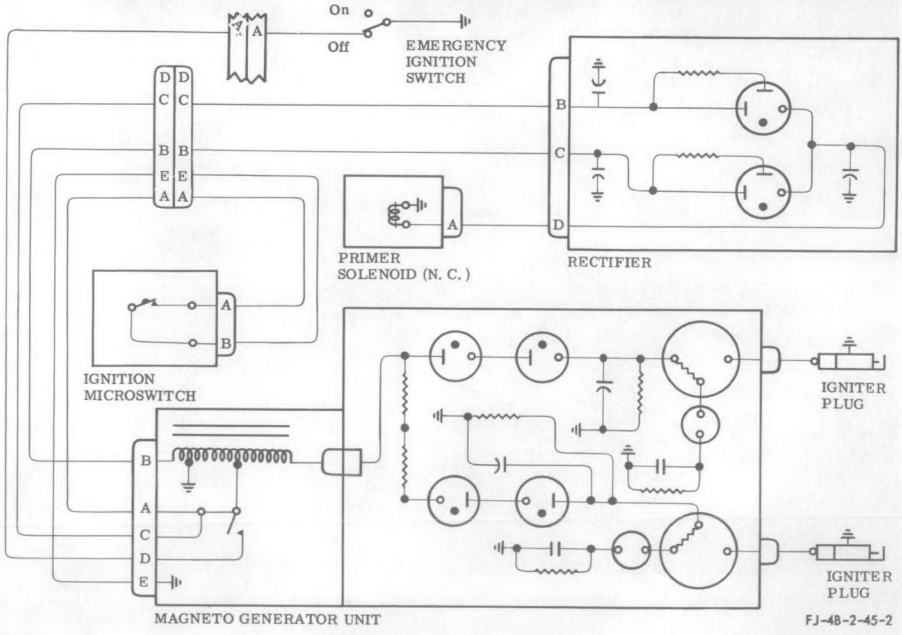


Figure No. 5-22. Engine Ignition System

IGNITION SYSTEM

5-90. IGNITION SYSTEM.

5-91. The ignition system (figure 5-22) consists of an ignition unit which contains a magneto generator and a capacitance discharge-type ignition unit assembly, mounted on the forward face of the accessory gear box, a rectifier unit, two igniter plugs, a primer valve solenoid, a power control lever microswitch, located on the engine fuel control unit, and an emergency ignition switch (EMERGENCY IGNITION) located on the left-hand forward console in the cockpit.

5-92. FUNCTION OF IGNITION SYSTEM—NORMAL OPERATION.

5-93. When the engine has reached 11% rpm by starter action, the ignition system (figure 5-22) functions as follows: Moving the power control lever forward from the "OFF" position actuates a microswitch located on the engine fuel control unit. With this switch in the open position, the magneto generator supplies voltage through the ignition unit to the igniters. When the engine reaches 22.9% rpm, a centrifugal switch closes and routes current from the magneto generator to ground through the emergency ignition switch. This action also de-energizes the normally closed primer valve solenoid and stops the flow of fuel to the primer jets.

5-94. FUNCTION OF IGNITION SYSTEM—EMERGENCY OPERATION.

5-95. In the event of an air start when the engine is windmilling above 22.9% rpm, or if the centrifugal switch should malfunction, an emergency ignition switch is provided. The emergency ignition system (figure 5-22) functions as follows: When the engine is windmilling above 22.9% rpm, the centrifugal switch closes and the magneto generator current goes to ground through the emergency ignition switch. Placing the EMERGENCY IGNITION switch to the "ON" position will break the ground circuit from the magneto generator which, in turn, will energize the primer solenoid valve to the open position and permit the magneto generator to supply voltage through the ignition unit to the igniters.

CAUTION

The duty cycle for the emergency ignition system is 3 minutes on, 2 minutes off—3 minutes on, 23 minutes off.

5-96. CHECKING IGNITION SYSTEM.

5-97. To check the ignition system, proceed as follows:

WARNING

Make absolutely certain that any accumulated fuel has drained from the engine before making these checks. Also, make sure that there are no fuel fumes in the immediate area at the time these checks are made.

a. Through the engine access door on the bottom of the fuselage, disconnect the ignition lead at the microswitch connection on the bottom aft side of the fuel control unit. This opens the magneto generator ground lead and permits the igniter plugs to fire while the engine is rotating at 11% rpm or above (with the power control lever in the "OFF" position).

b. Place the power control lever in the "OFF" position.

Note

The following checks will require two men, one in the cockpit to operate the controls and one on the ground to check the igniter plugs.

c. Connect an external power source to the airplane.

d. Place the ENGINE MASTER switch in the "MASTER" position.

e. Motor the engine with the start-stop switch (STARTER) located on the left-hand console.

f. Listen closely to make certain that both igniter plugs are firing.

g. If either or both of the igniter plugs fails to fire, proceed with the trouble isolation procedures outlined in paragraph 5-98.

h. Place the ENGINE MASTER switch in the "OFF" position.

i. Disconnect external power source from the airplane.

j. Remove and replace any igniter plug that is defective.

k. Reconnect the ignition lead to the fuel control unit at the microswitch connection.

WARNING

The output of the ignition system is sufficient to cause severe injury from electrical shock. Never come in contact with any uncovered or live portion of the system during operation.

CAUTION

When making the preceding checks, do not engage the starter for longer intervals than 15 seconds; permit sufficient time between checks for the starter-generator to cool.

5-98. ISOLATING TROUBLE IN IGNITION SYSTEM.

5-99. In case of ignition system failure, the trouble should be isolated as follows:

a. During ignition check, if both igniter plugs fail to fire or if the spark rate is too slow or too fast, the trouble is probably incorrect output of the ignition unit. To check, replace the ignition unit assembly with a serviceable item.

b. If one igniter fails to fire properly, check the igniter plug lead, the connectors and the igniter plug.

c. If the igniter plug still fails to fire, replace the ignition unit with a serviceable item.

d. During a start, if both igniter plugs fail to fire and the primer valve is open, check the position of the ignition system microswitch. If the power control lever is in the "OFF" position, the switch should be closed; if the power control lever is in any other position, the switch should be open. If the ignition system microswitch is not operating properly, check the position of the tab that actuates the microswitch. This tab is located on the fuel control unit and is operated by the engine control lever. The tab may be bent out of position so that the microswitch will not function properly.

e. During a start, if both plugs fail to fire and the primer valve and the ignition system microswitch are open, the trouble is probably in the ignition unit.

f. If both igniter plugs continue to fire after the engine has reached 22.9% rpm and the primer valve solenoid has remained open, check the EMERGENCY IGNITION switch to make sure it is in the "OFF" position. If the switch is in the "OFF" position, the centrifugal switch has probably remained open.

CAUTION

During engine run-up, if hot spots appear on the combustion chamber in the vicinity of the priming jets, it is a good indication that the priming valve solenoid has remained open and has allowed fuel to be injected into the priming jets after the starting cycle has been completed.

5-100. IGNITION SYSTEM IGNITION UNIT.

5-101. The ignition unit contains a magneto generator and a capacitance discharge-type ignition unit assembly. The magneto generator assembly contains a 14-pole rotor, a modified magneto coil winding and a two-pole centrifugal switch. The centrifugal switch is a normally open switch which closes when the engine reaches 22.9% rpm. At 9.5% rpm, the unit begins to produce sufficient voltage for engine ignition. The ignition unit assembly is of the capacitance discharge-type in which the voltage from the magneto generator is stored in storage capacitors.

5-102. IGNITION SYSTEM RECTIFIER UNIT.

5-103. The rectifier unit is mounted on the bottom of the engine on the left front side of the compressor housing. When the engine is below 22.9% rpm, alternating current from the magneto generator flows through the rectifier to the primer valve solenoid and energizes the normally closed solenoid to the open position. When the engine reaches 22.9% rpm, the centrifugal switch closes and current flows directly to ground through the emergency ignition switch, by-passing the rectifier unit. The primer valve solenoid is de-energized to the closed position.

5-104. IGNITION SYSTEM IGNITER PLUGS.

5-105. The two igniter plugs are installed in the combustion section of the engine. One igniter plug is located at the 4 o'clock position and the other is located at the 10 o'clock position (when viewed from the rear of the engine). Access to the igniter plugs for removal or installation may be gained by removing the aft fuselage section from the airplane.

5-106. IGNITION SYSTEM PRIMER VALVE.

5-107. The primer valve, mounted on the bottom of the engine on the left rear side of the compressor housing, is a solenoid-actuated normally closed valve. The solenoid permits the primer valve to supply fuel to the primers for the starting sequence. The solenoid is energized to the open position by action of the magneto generator until the engine has reached 22.9% rpm. Access to the primer valve solenoid for removal or installation may be gained through the engine access door on the bottom of the fuselage.

5-108. IGNITION SYSTEM MICROSWITCH.

5-109. The ignition system microswitch, located in the fuel control unit, is a single-pole, single-throw switch that is actuated through mechanical linkage by the power control lever in the cockpit. When the power control lever is moved forward, past the "OFF" position, the switch is open. When the switch is in the closed position, magneto generator current flows through the switch to ground. When the switch is in the open position, this ground connection is broken and the current from the magneto generator must flow in another direction to the igniter plugs such as in the case of the engine starting sequence.

5-110. IGNITION SYSTEM EMERGENCY IGNITION SWITCH.

5-111. The emergency ignition switch (EMERGENCY IGNITION) is a single-throw switch located on the left-hand forward console. With the switch in the "OFF" position and the engine over 22.9% rpm, current flows from the magneto generator to ground through the switch. When the switch is placed in the "ON" position, when attempting an air start with the engine windmilling above 22.9% rpm, the circuit is interrupted and current flows to the ignition unit to fire the igniter plugs. Also, sufficient voltage flows to the rectifier unit and the primer valve solenoid to energize the normally closed solenoid valve to the open position.

ALPHABETICAL INDEX

PAGE NUMBERS IN *ITALICS* DENOTE ILLUSTRATIONS

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